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Description and Habits of the Spruce Seedworm, (*Laspeyresia youngana* (Kft.) (Lepidoptera: Olethreutidae)[1]

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Introduction

Cone-infesting insects have been recognized for many years but have not attracted as much attention as some of the defoliating species. The apparent lack of interest is quite understandable since seed destroying insects are seldom, if ever, a problem in natural reproduction. White spruce successfully reproduces, despite the numerous insects which are known to feed on the seeds. However, the increased interest in reforestation necessitates the collection of cones and extraction of the seed to supply the demands of forest nurseries. During heavy cone-crop years, enough seed must be extracted and stored to provide a supply for the years when cones are scarce. As all conifers generally produce an abundance of cones the same year, the number of bushels which may be processed for any one species is limited. As a consequence, cone-infesting insects have become a factor of considerable importance.

It was suggested by the Superintendent of the Seed Extraction Plant of the Ontario Department of Lands and Forests that a study be made to determine the part insects played in seed destruction and a possible control for the species involved. Accordingly, a program was arranged by the Division of Forest Biology to study the biology of white spruce cone insects. The investigation was begun by W. J. Morley in 1948 and continued by the writer in 1950. The portion of the investigation dealing with one of the primary pests, *Laspeyresia youngana* (Kft.), is presented in this paper.

Review of Literature

Early work on the spruce seedworm, *Laspeyresia youngana* (Kft.), was mainly of a taxonomic nature but some later workers made observations on the biology of the species. The first record was made by Charles H. Young of Hurdman's Bridge, Ottawa. Nine specimens reared by Young were used by Kearfott (12) in 1907 to describe the species. He named it *Enarmonia youngana* in Young's honour. The species was classified in the family Eucosmidae under the new generic name *Laspeyresia* Hüber by Barnes and McDunnough (1). Forbes (3) placed the species in the subfamily Eucosminae of the family Tortricidae. Heinrich (9) included the subfamilies Olethreutinae, Eucosminae, and Laspeyresiinae under the family Olethreutidae with this species in the subfamily Laspeyresiinae. The family name Eucosmidae is considered synonymous with Olethreutidae (6). For further information on the classification of this group of micro-lepidoptera the reader is referred to Heinrich's "Revision of the North American moths of the subfamilies Laspeyresiinae and Olethreutinae".

Recently, Daviault (2), Morley (14), and Hedlin and Hovey (8) published short accounts on the habits of *Laspeyresia youngana* (Kft.).

Hosts and Distribution

The species feeds in the cones of white spruce, *Picea glauca* (Moench.) Voss, red spruce, *Picea rubens* Sarg. (10 and 11), Sitka spruce, *Picea sitchensis*

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(Bong.) Carr. (9), Engelmann spruce, *Picea engelmanni* (Parry) Engelm. (13), and blue spruce, *Picea pungens* Engelm. (13). The insect has been found throughout Eastern Canada and the northeastern parts of the United States. In the west, it has been recorded from Montana, Oregon, Colorado, British Columbia, and Saskatchewan. It is probably widely distributed throughout the range of its host trees.

Methods

The presence of the seedworm was detected by dissecting the cones but it was not possible to keep the insects alive. Consequently, the habits of individual larvae could not be observed from day to day. This fact necessitated the periodic collection and examination of cone samples. The main procedure was to collect as many cones as could be conveniently handled and to dissect each one, scale by scale from the base, beneath a dissecting microscope. The data on populations and habits were recorded on various forms designed for the purpose. Specimens were preserved in 70 per cent ethyl alcohol.

In 1950, the chief source of material was from Stittsville, Ontario, where five white spruce trees with medium to heavy cone crops were chosen. Five cones from each tree constituted a sample. During the month of May, a sample was taken every day, during June, every second day, and during July and August every third day. Since most of the insect feeding had ceased by September, samples were taken from September to December at irregular intervals. Individual white spruce trees near Dunrobin, Huntley, and South March, Ontario were also selected for sampling. Somewhat irregular but numerous samples were taken from these trees.

Unfortunately, in 1951 and 1952, the cone crops were very light and the infestations quite high. It was found that to secure all the desired data and to avoid stripping the sample trees, the sample size had to be reduced. Only about five cones were examined in detail in one day. In addition to sampling current cones, old 1950 cones were sampled for the presence of larvae in diapause. These cones were collected in lots of about one hundred from about eighty trees throughout southern Ontario and neighbouring parts of Quebec.

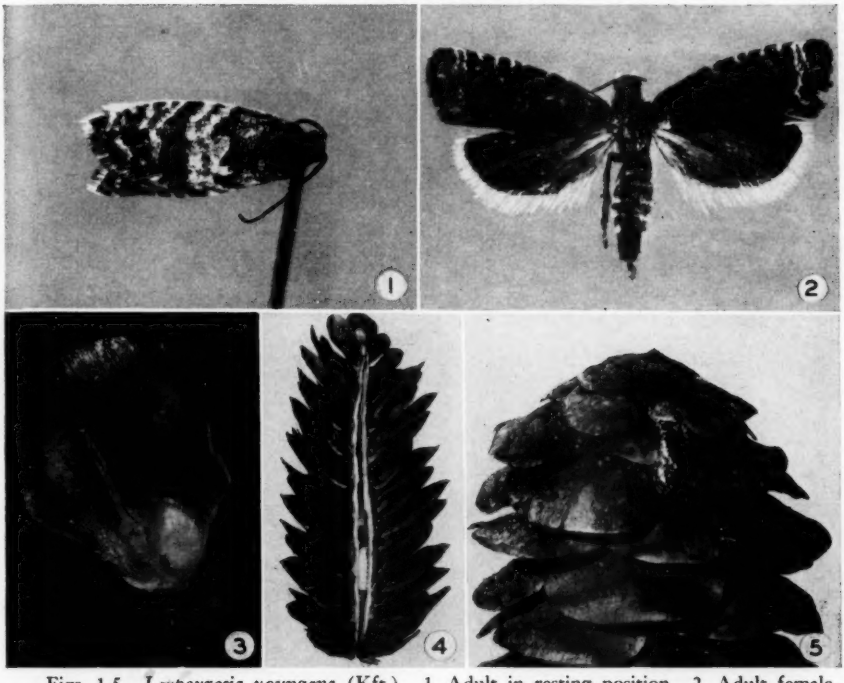
The successful rearing of the spruce seedworm was accomplished by placing a last-instar larva in a shell vial with a small piece of crumpled paper, so that it might successfully spin up in the folds. Each vial was stoppered with a cotton plug which served as a wick to supply moisture.

Temperature records were, for a time, taken at the sample trees. It was soon learned, however, that these did not vary appreciably from those taken by the Meteorological Unit, Experimental Farm, Ottawa, 13 miles distant. Consequently, the records from the Experimental Farm were used in this study.

Description of the Insect

Adult

The moths have a wing expanse of 8 to 11 mm. They appear somewhat smoky-brown with four cross bands of shining silver and four additional shining costal spots (Figs. 1 and 2). Variations within the species result in a few disagreements with the original description. Kearfott (12) stated that from the second pair of white costal spots on the forewing runs a single streak of blue-metallic. In the majority of specimens examined, the apical spot of the pair does not join the single streak but ends abruptly and is entirely separate from the



Figs. 1-5. *Laspeyresia youngana* (Kft.). 1, Adult in resting position. 2, Adult female. 3, Injury by first-instar larva. 4, A hibernating larva. 5, Pupal skin, just after adult emergence, showing portion of silk tube at base.

other costal spot. Kearfott describes seven costal spots but most specimens have eight.

There is considerable variation in wing venation between individuals (Fig. 6). As a result, keys based solely on wing venation are not always successful with this species. The most obvious variation in the forewing is the presence or absence of a partial first anal vein (Fig. 6 A & B). Variations in the hind wing are more pronounced. The degree of fusion of the third median and first cubitus varies considerably. The basal forking of the second anal vein of the hind wing is a common characteristic of Olethreutids but in some *Laspeyresia youngana* it is not apparent.

The wing venation of this species indicates that it might better fit in the genus *Carpocapsa*. In writing of the genus *Carpocapsa*, Forbes (3) states:

> "The genus is of moderate size; the larvae feeding in fruits and seeds. It . . . has only a single introduced species in the Northeast, the famous codling worm . . . . The genus is hardly distinct from *Laspeyresia*. I have placed *C. toreuta* and *erotella* here temporarily, following Heinrich. They are not true Carpocapsas but as far as I know they have no valid generic name. The whole group they represent are feeders on conifers. *Laspeyresia youngana* should probably be grouped with them."

Both male and female genitalia have been illustrated by Heinrich (9). His figures resemble very closely the specimens at hand.

Egg

Freshly laid eggs are almost spherical with a diameter of about 0.5 mm. At first they are pale orange, tending to become dark as the embryo develops. The

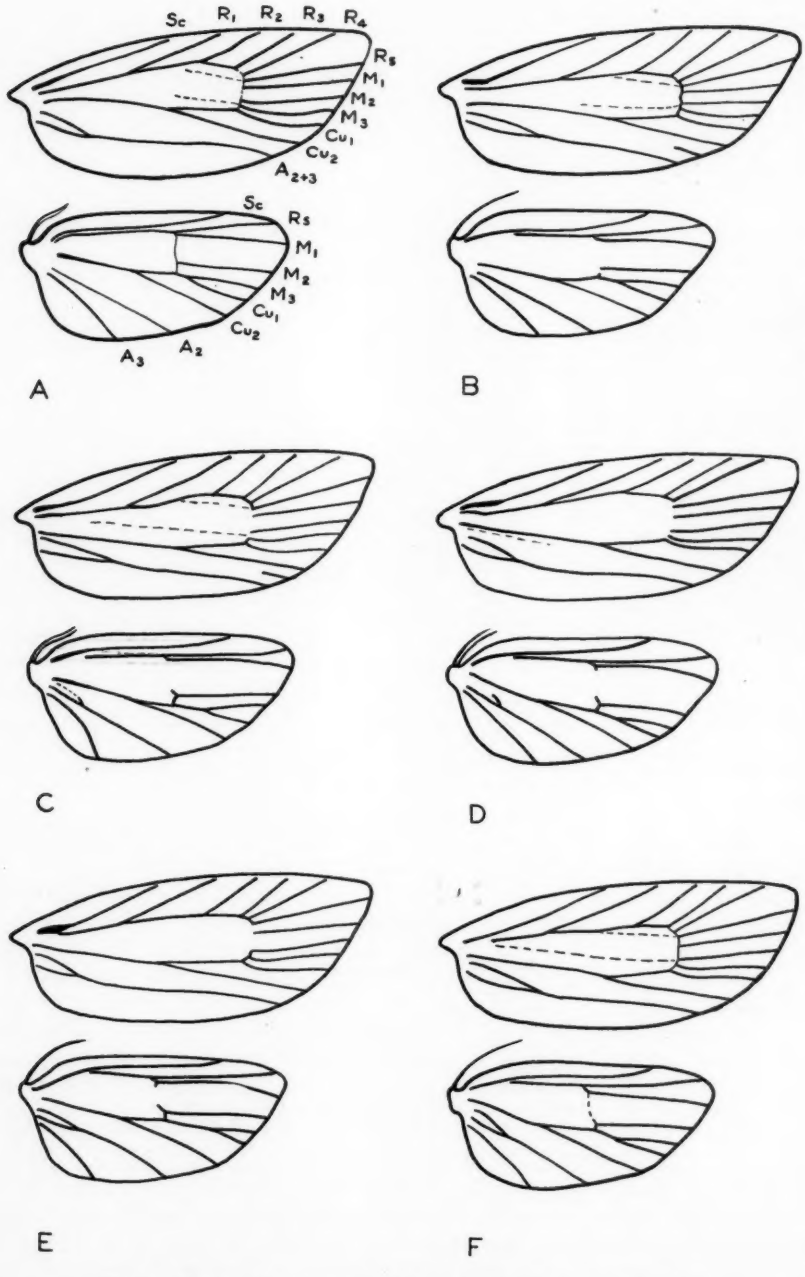


Fig. 6. *Laspeyresia youngana* (Kft.). Variations in wing venation.

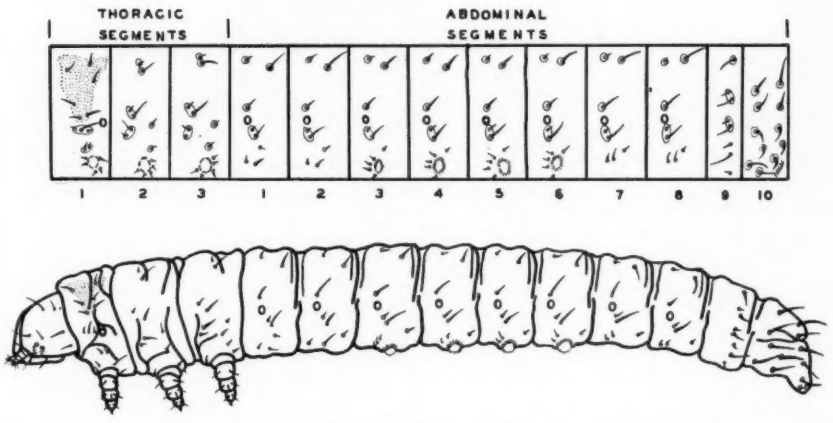


Fig. 7. *Laspeyresia youngana* (Kft.). Last-instar larva and setal map.

chorion is smooth and pliable. Consequently, eggs become variously shaped when they are compressed between the cone scales. Eggs deposited in the productive area of the cone tend to become flattened while those deposited in the non-productive apical portion tend to retain their original shape. Occasionally, an egg may be compressed between the edges of two adjoining scales and thus become triangular in shape. Although their position in a cone follows a definite pattern, distortion of shape due to pressure of the scales does not appear to have any effect on mortality.

Larva

Last-instar larvae are creamy-white with the head and prothoracic shield brown. Full-grown larvae are about 10 mm. in length with an average head-capsule width of 0.75 mm.

Considerable variation in setal pattern is found within the species (Fig. 7). Variation is most apparent on segment nine, where seta *mu*[1] is often closely associated with *kappa* and *eta*, but never appears on the same pinaculum. *Mu* is illustrated as being distant from the *kappa* group. As a result of this variation, larvae will not always key out to the genus *Laspeyresia* but rather to *Carpocapsa*. Fracker (5) acknowledged great individual variation within the family and in writing of the family Tortricidae stated:

> "Individual fluctuating variations are rather confusing in an attempt at classification . . . . Greater difficulties are met in working with the genera. The writer has not found absolutely constant characters to distinguish the genera of this family . . . ."

The genera *Laspeyresia*, *Carpocapsa*, and *Grapholitha* are very closely related. European writers often include them under the one genus, *Cydia* (4).

The crochets are arranged in a uniordinal circle which tends to become somewhat pear-shaped on some larvae. The number of crochets on each planta varies from seventeen to twenty-four, and bilateral symmetry usually prevails. When a planta bears a reduced number of crochets, a gap is apparent at the top. The crochets on the anal prolegs are arranged in a uniordinal, slightly curved line of from three to six in number.

[1]Nomenclature after Fracker.

B & Z LIBRARY

Pupa

The pupae are normally a light amber colour, but change to deep brown to black just prior to emergence of the adult. The tergum of abdominal segments two to seven typically bears two transverse rows of triangular-shaped spines. The anterior row in each case is the larger and more prominent (Fig. 8).

Male and female pupae differ in many respects. Some of these differences are very useful for "sexing". A comparison of the pupae of both sexes reveals that the female abdomen is larger (Table 1).

TABLE I

Comparison of the length of male and female pupae.
Laspeyresia youngana (Kft.)

	Sex	Number	Degrees of Freedom	Mean Length in Units. 100 Units = 5.5 mm.	Sum of Squares
Length of Forewing.....	Male	12	11	48.8	142.88
	Female	21	20	52.7	368.29
		33	31	Difference 3.9	511.17
		t = 3.225;	P =	< 0.01	
Length of Thorax.....	Male	12	11	29.5	
	Female	21	20	29.5	
				Difference 00.0	
Length of Abdomen.....	Male	12	11	50.8	575.68
	Female	21	20	64.7	1022.69
		33	31	Difference 13.9	1598.37
		t = 6.5 ;	P =	< 0.01	

There is no appreciable difference in the length of the thorax, although the female possesses slightly longer forewings. The average overall length of the male is 4.5 mm.; the female exceeds the male on the average by 0.8 mm. Nevertheless, size alone is not a good criterion for separation as there is considerable overlapping.

A more constant characteristic for sex differentiation is the length of the antennae. Those of the male extend beyond the mesothoracic legs; those of the female are much shorter, seldom extending beyond the mesothoracic legs. Pupae may be sexed by this characteristic without the aid of magnification.

There is also a slight difference in the dorsal spines. The posterior row of spines on the seventh abdominal segment of the female is reduced in numbers or wanting, but in the male the spines are fully developed. They are usually wanting on the eighth abdominal segment of the female, but the anterior row at least is strongly developed in the male. In male pupae the genital opening appears on the ninth sternum but in the female it occurs on the eighth.

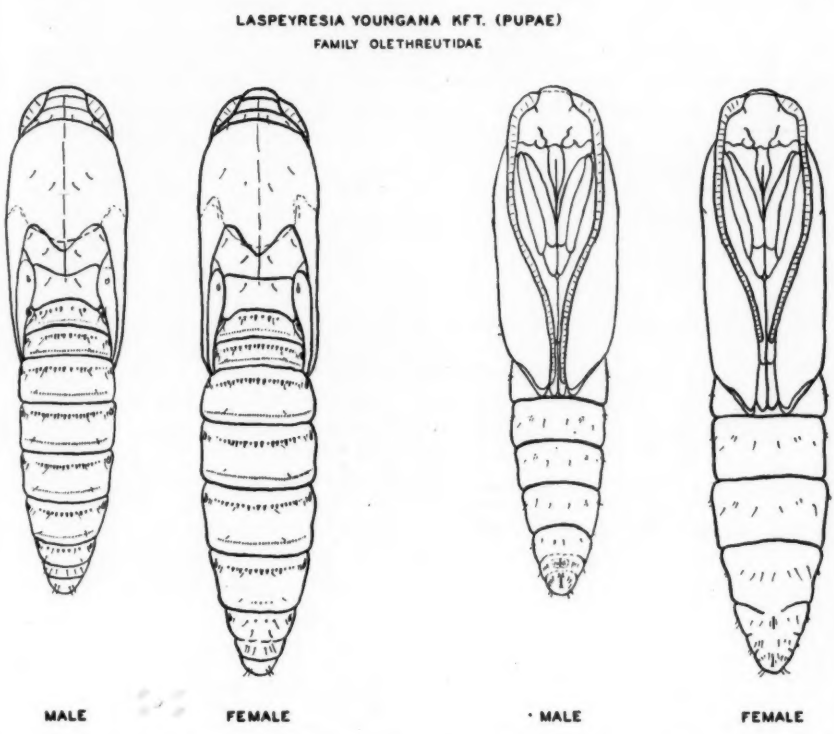


Fig. 8. *Laspeyresia youngana* (Kft.). Pupae showing sexual differences.

Life History and Habits

Adults

Adults were observed to emerge in the insectary during the month of May (Table 2). In 1950, maximum emergence occurred on May 23, in 1951, on May 15. The difference of eight days between the two years was probably the result of higher temperatures during April, 1951 (Fig. 9). Moths were observed in the field at the same time as emergence occurred in the insectary.

It was apparent by field observations and by observing caged specimens that the females were reluctant to fly. Careful search in the field revealed them resting on the twigs. They usually moved by crawling over the foliage and on to the cones, but if disturbed they would flutter off and settle a few inches away. The males, on the other hand, were extremely active, swarming near the cones on warm bright days.

A further indication that female moths do not travel great distances was shown by the heavy infestations on old cone-bearing trees. Young trees were seldom attacked, unless situated near an older tree. Cones from an Ottawa nursery, where the trees were isolated from mature spruce, were uninfested. It seems apparent that the infestation tends to build up on individual trees and then spreads slowly throughout the area.

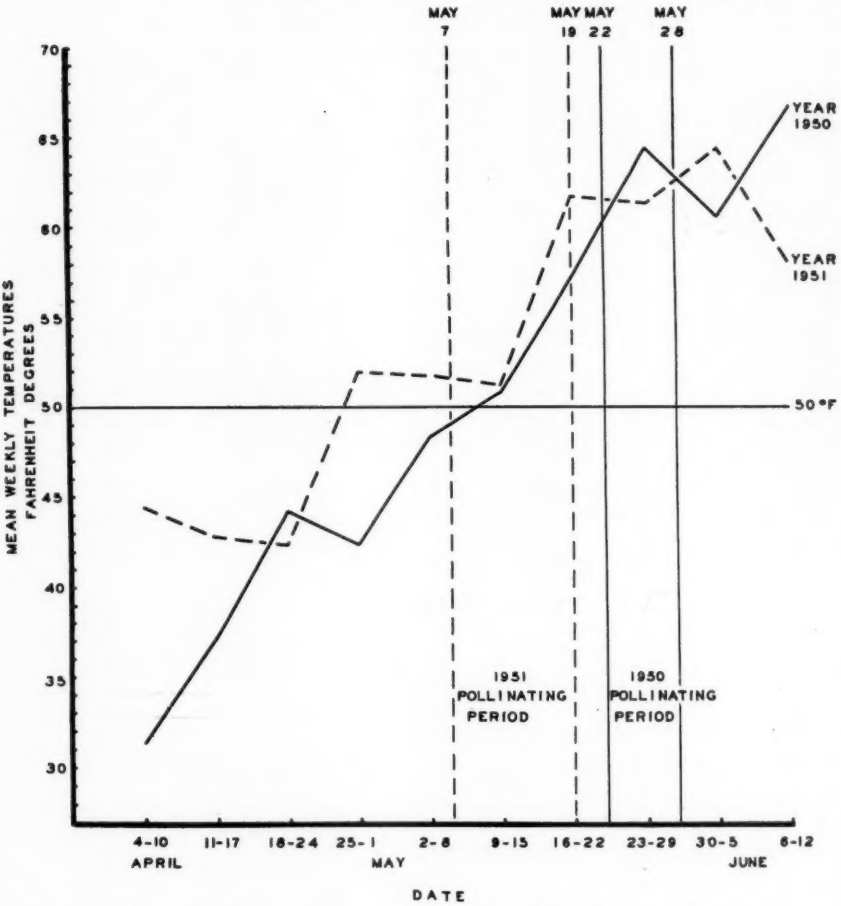


Fig. 9. Weekly mean temperatures in 1950 and 1951, Ottawa, Canada.

TABLE II

Laspeyresia youngana Kft. Record of adult emergence, 1950.

Date of Emergence	Females	Males
May 22	1	8
May 23	10	10
May 24	10	1
May 25	0	0
May 26	1	2
May 27	0	0
Total	22	21

Five days after the peak of emergence in 1950, it was extremely difficult to locate moths in the field. This indication of a short flight period was borne out by the caged specimens. The females seldom lived beyond the fifth day; the males lived a little longer. Two males were kept alive for eleven and twelve days respectively.

When moths first emerged, cones were collected and examined for the presence of eggs. It was found that egg laying began shortly after the moth emergence. Cones were found to contain eggs on May 25, 1950, only three days after the first record of emergence. By watching freshly-emerged caged specimens, copulation was observed to occur almost immediately; eggs were deposited the following day.

Details of egg laying were difficult to obtain as the females were easily disturbed. However, they appeared to deposit only a single egg between the cone scales at one setting. In 1951, when the cones were quite scarce, it was observed that a single cone was visited by many different females. This, of course, was indicated by the large number of eggs per cone in that year (Fig. 10). Well over 90 per cent of the cones were infested and of these the majority contained about 12 eggs. In 1950, when cones were abundant, the majority of infested cones were found to contain only a single egg and only about 50 per cent of the cones were infested (Fig. 10). It is evident that the average number of eggs per cone depends on the number of available cones.

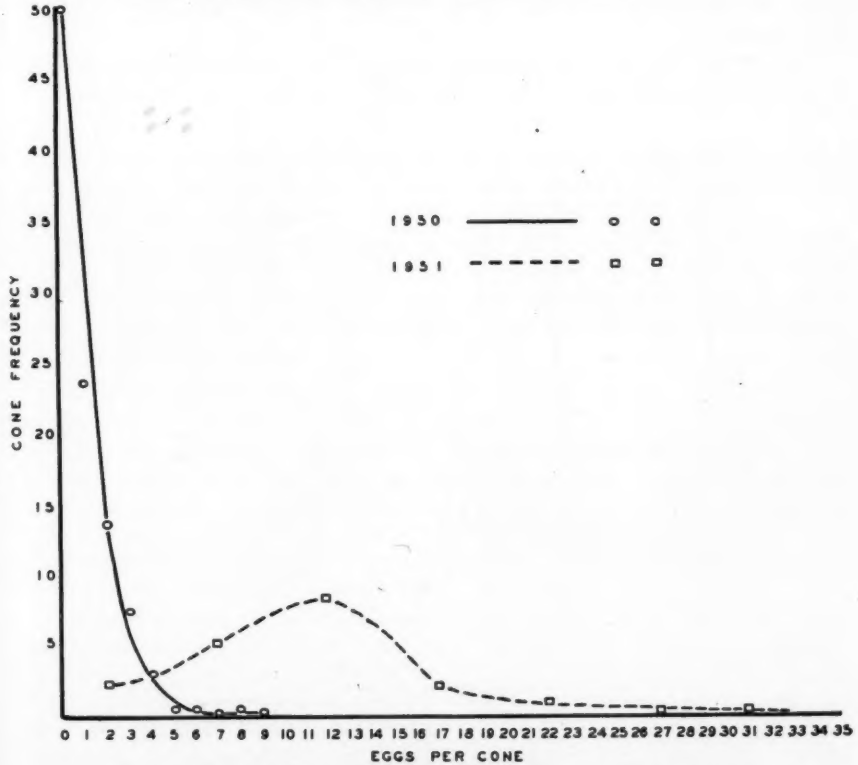


Fig. 10. *Laspeyresia youngana* (Kft.). Eggs per cone, 1950 and 1951.

To determine the fecundity, males and females were paired and caged with three or four cones. Many of the females died without laying eggs but three females were observed to oviposit. They were later dissected and a total of 28 eggs were found. Dissection of the cones revealed 153 eggs for a total of 181 or an average of 60 eggs per female. Dissection of four females that did not oviposit revealed an average of only 32 eggs per moth.

Eggs

Incubation period

Daily cone samples of twenty-five in 1950, and five in 1951, were examined for the presence of eggs and larvae. Eggs were first observed on May 25, 1950 and May 17, 1951 (Figs. 11 and 12). Although there was an eight-day difference, egg laying began in each case when the average weekly temperature was about 60°F. (Fig. 9). In 1950, larvae first appeared on June 4, and in 1951, on May 27. For both years, the interval between first oviposition and first appearance of larvae indicated an incubation period of ten days.

Oviposition period

Eggs were present for twenty-four days in 1950 (Fig. 11); in 1951, they were present for twenty-six days (Fig. 12). However, many of the eggs present during the latter parts of these periods were considered non-viable; in each case, further hatching was not apparent after the twentieth day. Assuming the incubation period was ten days, egg laying must have continued for about ten days.

Egg distribution

In 1951, by mapping the position of 424 eggs from 63 cones, over 80 per cent were observed in the apical half of the cones (Fig. 13). At the beginning of

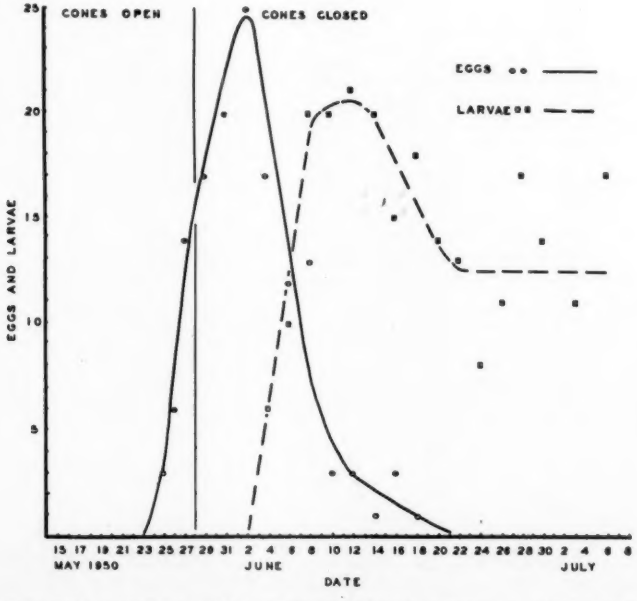


Fig. 11. *Laspeyresia youngana* (Kft.). Eggs and larvae present in cones during May 15-July 6, 1950.

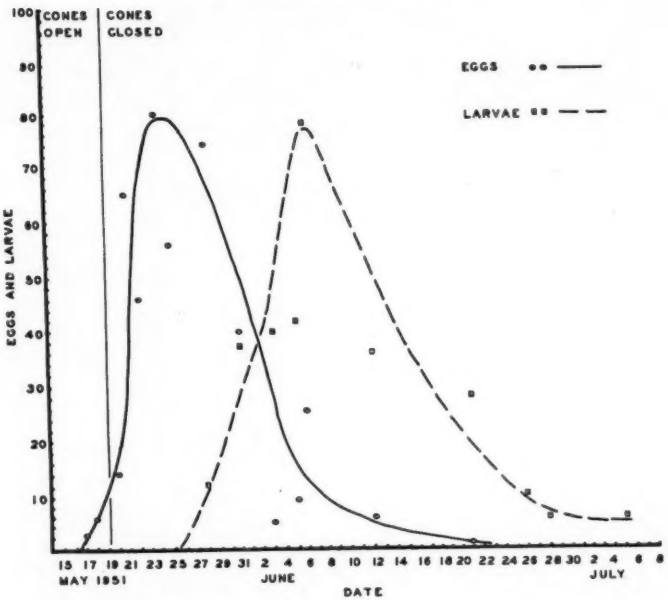


Fig. 12. *Laspeyresia youngana* (Kft.). Eggs and larvae present in cones during May 15-July 6, 1951.

oviposition, eggs were deposited at random throughout the cones. The cone scales were all open at this time, but, as the scales closed progressively from the base, more eggs were eventually deposited in the apical half.

A concentration of eggs toward the apex was not apparent in 1950. This may be readily explained. Oviposition was well advanced before cone closure (Fig. 11), whereas in 1951 (Fig. 12), it was just beginning as the cones began to close. The slight delay in oviposition in 1951 was probably due to difficulty by moths in locating cones.

Larvae

Instars

The determination of the number of instars presented a problem. The obvious method of rearing larvae to observe moults was impractical with this insect; no method was found to keep them alive after the cones were dissected. However, by counting the number of cast head capsules, the minimum number of instars was established. No more than three head capsules, indicating four instars, were located from a single larva.

To check this conclusion, the head-capsule widths of 448 larvae—collected periodically during 1950—were measured. The resultant frequency distribution exhibited five pronounced peaks (Fig. 14). The first and second peaks obviously represented the first and second instars, but the final three peaks overlapped. By using the statistical method of analysing polymodal frequency distributions on probability paper as described by Harding (7), these three peaks indicated three distinct populations.

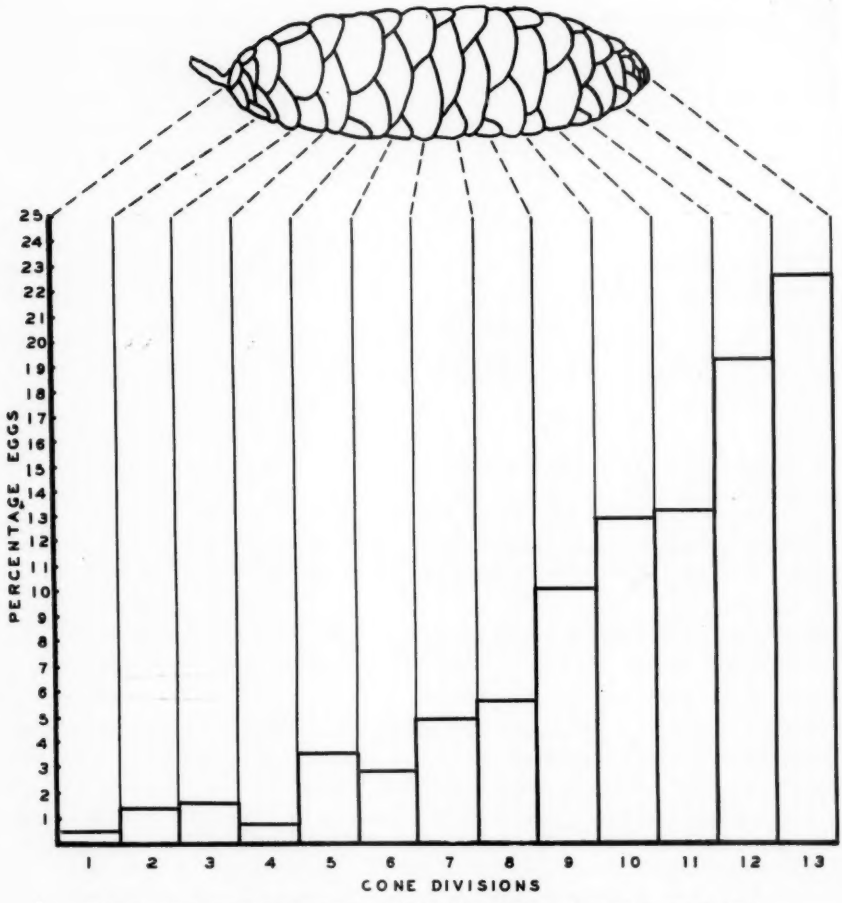


Fig. 13. *Laspeyresia youngana* (Kft.). Distribution of eggs in cones, 1951.

It was decided to check the data with a different set of larvae. The head capsules of one hundred larvae—that had entered diapause and therefore were known to be in their last stadium—were measured. The resultant distribution (Fig. 15) clearly indicates that the fourth instar occurs in two different sizes.

Attempts to determine the sex of the larvae were unsuccessful as the gonads were not discernible. However, the pupae were readily sexed making it possible to keep the cast head capsules of males and females separate. It was impractical to measure the width of the entire head capsule because they were split along the frontal suture and often broken in other ways. The clypeus, however, always remained intact; its width was measured using two basal setae as markers. The resultant frequency distributions showed the average width of the female clypeus larger than that of the male (Fig. 16). The mean difference is significant, the probability of a null hypothesis being less than one per cent.

Stadia

The stadia was estimated by using the same larvae as employed for head-capsule measurements. As the dates of collection of the various larvae were

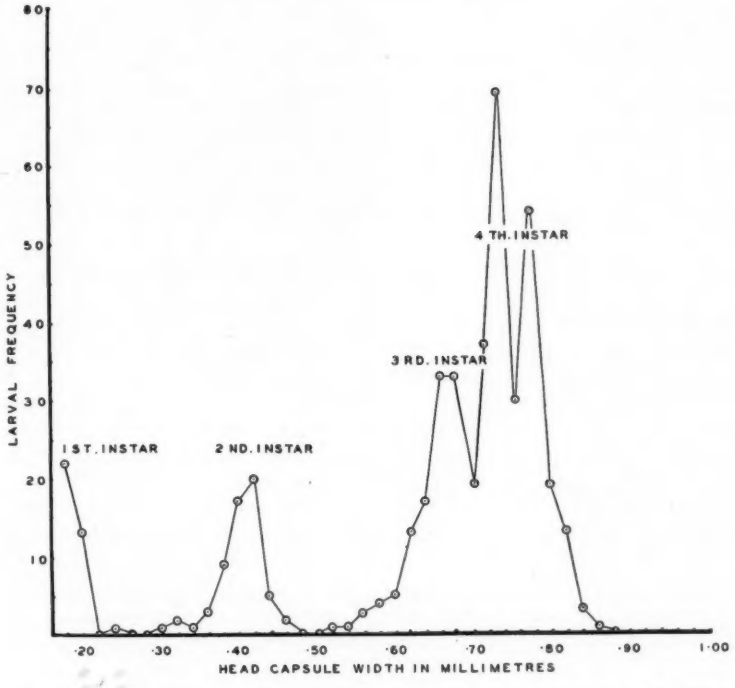


Fig. 14. *Laspeyresia youngana* (Kft.). Head-capsule widths. Frequency distribution from May to December, 1950.

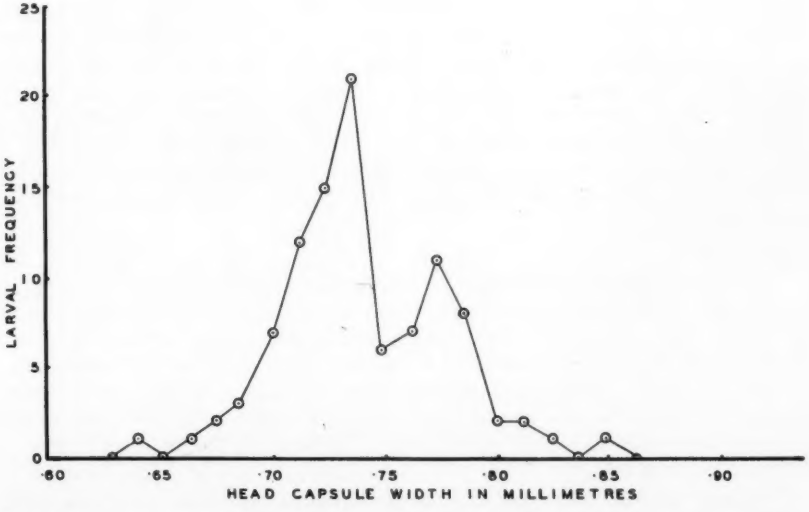


Fig. 15. *Laspeyresia youngana* (Kft.). Head-capsule widths of larvae in diapause, 1951

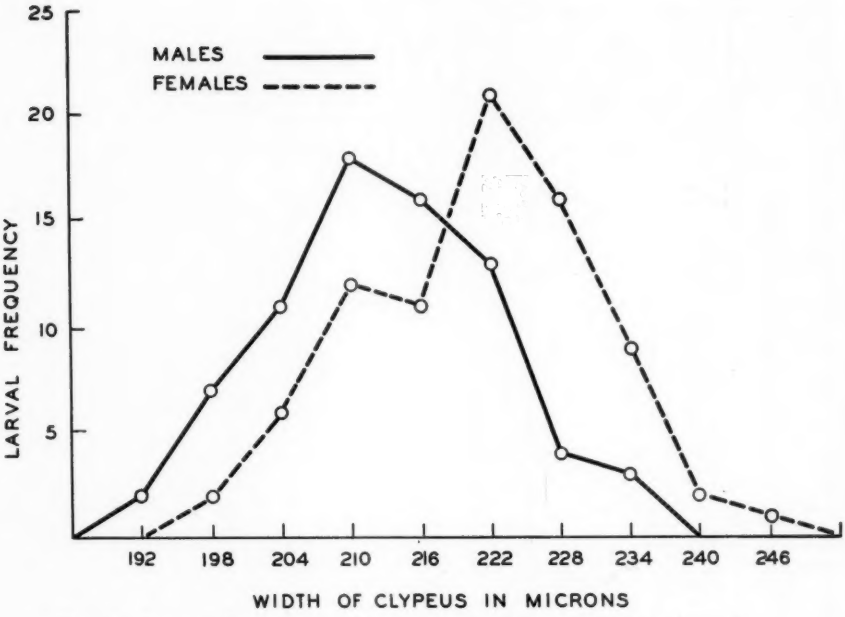


Fig. 16. *Laspeyresia youngana* (Kft.). Clypeal measurements of last-instar larvae.

known, the only problem was the correct identification of the instars. Following are the estimates of the means and ranges for the instars:

INSTAR	MEAN HEAD-CAPSULE WIDTH	RANGE
First	0.20 mm.	0.175 to 0.230 mm.
Second	0.40 mm.	0.300 to 0.460 mm.
Third	0.65 mm.	0.520 to 0.780 mm.
Fourth	0.76 mm.	0.660 to 0.860 mm.

It was possible to be reasonably certain as to the instar of the first two, but errors in the identification of the third and fourth instars were certain to have occurred. However, errors were kept to a minimum by disregarding those doubtful larvae with head-capsule measurements between 0.660 mm. and 0.780 mm. The result of the study showed the first stadium to be about one week, the second ten days, and the third about three weeks; fourth-instar larvae hibernated (Fig. 17).

Larval habits

The newly-hatched larva enters a scale and mines toward a developing ovule. Occasionally a larva enters and feeds within an ovule on the same scale (Fig. 3) but it may mine four or five scales before entering an ovule. Here it moults to the second instar leaving the exuviae along with the frass within the seed coat.

Second-instar larvae continue to hollow out ovules, passing from one to another through or around the bases of the scales. During this stadium, feeding is confined for the most part to the ovules; the scales make up little, if any, of the food consumed.

During the third week of June, larvae moult to the third instar and within a day or two enter the rachis of the cone. Entry occurs in the apical half,

usually at a point one-third of the distance from the apex to the base. Immediately after entry they tunnel in the rachis to nearly the base of the cone. The resulting frass is packed into the apical part of the tunnel where it blocks off the entrance hole (Fig. 4). If more than one larva should gain access to the rachis, cannibalism usually occurs, leaving a single larva per cone; if, however, the cone is unusually large, two or more may survive in a single cone. In such cases, the larvae are separated from each other by a plug of frass. They continue to feed on the ovules by boring holes from the rachis; a single larva may construct two or three such feeding holes. The frass is usually tucked into the depleted ovules.

About the middle of July the larva moults to the fourth instar. The cast skin is usually deposited in one of the ovules but is sometimes left in the rachis. The fourth-instar larva continues to feed until the beginning of September. It then makes an exit hole near the base of the cone where it spins a short tube of silk to the exterior between the scales. Having provided an avenue of escape for the moth, it retreats to the rachis, seals off all the holes with boring dust, and hibernates until spring

In the spring, just prior to pupation, each larva lines the rachis with loosely woven silk. If the cone is split open before pupation, the larva crawls between the scales and spins a cocoon. When a larva prepares for pupation in a location other than the undisturbed rachis, it spins more silk, constructing a rather tightly woven cocoon.

The larva usually lies with the head facing the exit hole but occasionally it pupates facing the apex. In such rare cases, emergence may take place through one of the feeding holes but the adult is generally unable to escape.

Larvae in diapause

Diapause, as used in this paper, refers to a physiological arrest of development, other than normal hibernation. In the life cycle of *L. youngana*, it is a

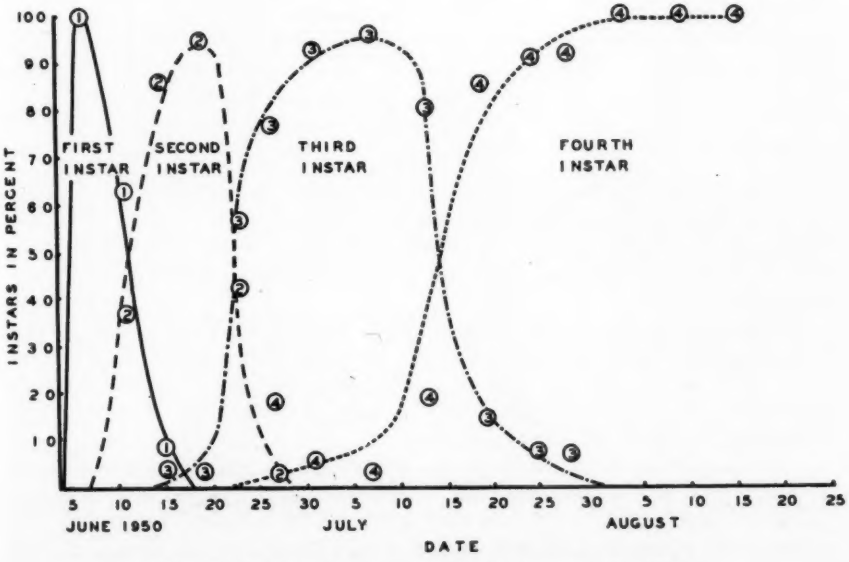


Fig. 17. *Laspeyresia youngana* (Kft.). Larval stadia, 1950.

prolonged period of arrested development not undergone by all the individuals.

There is reason to believe that the phenomenon of diapause did not occur among larvae from 1949 cones. During the spring of 1950, cones of the previous year were collected. From these, fifty apparently healthy larvae were segregated, one to a vial; forty-eight pupated and two died before pupation. Forty-five adults emerged. As diapause was not suspected at this time, no effort was made to locate larvae in this condition. Nevertheless, on the basis of the high percentage of pupation, it seems unlikely that larvae underwent diapause in 1950.

In the spring of 1951, larvae from 1950 cones were collected. Unlike the previous year, many larvae were observed to remain quiescent long after the normal pupation period. Further examination of 1950 cones revealed that larvae in diapause were common in the field (Table 3). About 41 per cent of the population emerged in the spring of 1951 and about 29 per cent entered diapause; the remaining 30 per cent did not survive the winter. Sampling of 1950 cones during the summer of 1952 revealed that some larvae remained in diapause for at least two complete years. From 867 infested cones, 24 larvae were found to extend their diapause to the second year. As both 1951 and 1952 were poor cone years, it appears that the phenomenon of diapause has a good survival value to the species during periods of fluctuating cone crops.

TABLE III

Analysis of 1950 white spruce cones during the summer of 1951 for *Laspeyresia youngana* (Kft.)

Locality	Quebec-Laurentian	Ottawa and vicinity	Renfrew Co. Simcoe Co.	Total
Cones examined	2550	2215	3375	8240
Percentage infested	18	45.3	6.2	21.6
Percentage larvae dead	27.5	31.2	27.4	29.5
Percentage emerged	41	41.7	42.4	41.6
Percentage in diapause	31.5	27.1	30.2	28.9

Pupae

Larvae were observed to overwinter and pupate in the spring but Daviault (2) stated that some manage to transform to pupae before winter. His illustration of the pupal stage clearly depicts cocoons of axis cecidomyiids. This mistake in identity could well lead him to the assumption that some seedworms pupated in the fall.

The pupa remains in the rachis until just prior to adult emergence. Then, with the aid of the dorsal spines, it works its way forward to the exterior until just the tip of the abdomen remains in the silken tube previously spun by the larva (Fig. 5). The pupal skin, however, generally falls from the cone as the adult emerges and is not usually found.

The length of the pupal stage was determined by examining cones in the field and also by rearing individuals in the insectary. In the field, the pupal period was about eighteen days in both 1950 and 1951, but by rearing at room temperatures adults may emerge in ten days. Pupae may be found, at least in the Ottawa Valley, during the first two weeks in May.

Generations per Year

Heinrich (9) stated that two generations occurred annually, adults appearing in April and May, and also in August and September. However, only one generation per year has been observed in southern Ontario; some larvae require two, three, or possibly more years to complete their life cycle.

Summary

The investigation of the biology of the spruce seedworm, *Laspeyresia youngana* (Kft.), was performed by periodically collecting samples of white spruce cones mainly in the vicinity of Stittsville, Ontario. Each cone was dissected, scale by scale, beneath a microscope and the data recorded on forms designed for the purpose.

The spruce seedworm infests the cones of white, red, Sitka, Engelmann, and blue spruces. It is distributed throughout Eastern Canada and northeastern United States and has been reported from Colorado, Montana, Oregon, British Columbia, and Saskatchewan.

The moths have a wing expanse of about 10 mm. They appear somewhat smoky-brown but the forewings exhibit four cross bands of shining silver and four additional shining costal spots. Freshly laid eggs are pale orange and almost spherical with a diameter of about 0.5 mm. They tend to become flattened between the cone scales. Full-grown larvae are creamy-white with head and prothoracic shield brown. They are approximately 10 mm. long. The pupae are light amber, about 5 mm. long, and are found in the rachis of the cone in light, loosely constructed, silken cocoons.

Moths emerge during the latter part of May and deposit eggs between the cone scales. When the cones are plentiful, usually only one egg is found per cone but as many as thirty-one have been observed when the cones are scarce. The majority of eggs occur in the apical half of the cone. They hatch in ten days. The larvae immediately bore into the cone scales and feed as miners for about a week, after which they feed in an ovule. Second-instar larvae feed freely upon the ovules and about the third week in June moult to the third instar and enter the rachis of the cone. The larvae are cannibalistic and usually only one larva becomes successfully established within the rachis. The rachis is hollowed out to the base and feeding is continued upon the ovules through holes excavated for the purpose. About the middle of July, they moult to the fourth and last instar and continue to feed until September. During September, they bore from the base of the cone to the outside, retreat to the rachis, and plug the hole with loose boring dust. Here they pass the winter. Pupation normally occurs in early May. About eighteen days later, the pupae work their way through the holes previously made by the larvae, and the adults emerge.

Some of the larvae do not pupate the first spring but remain in diapause for one, two, or possibly more years. The percentage of larvae that enter diapause is apparently correlated with the relative abundance of cones. During a heavy cone crop year, no "diapause" larvae were found but when cones were scarce, about 41 per cent entered diapause. There is, therefore, typically one generation annually.

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Rearing the Cadelle *Tenebroides mauritanicus* (L.) (Coleoptera: Ostomidae) as a Test Insect for Insecticidal Research[1]

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Introduction

The cadelle, *Tenebroides mauritanicus* (L.) is a common insect in ships, warehouses, mills and elevators. Back and Cotton (1926) state that it was well known as a pest of wheat in Europe before the end of the eighteenth century. According to Hatch (1942) in Europe the cadelle lives outdoors under bark and in rotten wood where it is predatory on xylophagous insects, and of the 152 species of the genus Tenebroides known by 1910 this was the only one reported as being injurious.

Although the cadelle is not considered to be of primary economic importance certain of its activities may lead to appreciable losses. For instance, damage to grain is out of all proportion to the amount consumed because of its habit of devouring the germ and leaving the rest of the kernel untouched. Its habit of boring into woodwork weakens wood structures and provides lodging places for other insects. Damage is also done by cutting holes in packages and bags, allowing spilling of the contents and the entrance of other species (Monro, 1951).

The cadelle was chosen as a test insect for experimental work in fumigation because it is often found in places where commercial fumigations are required and thus may provide an index for measuring the success of the treatments. Also its reactions to some of the commonly used fumigants differ from those of other stored product insects (Monro *et al.* 1952). Usually fourth instar larvae are used for the test work as this stage is more readily obtained than later stages and lends itself to observation more than do other stages.

[1]Contribution No. 28, Science Service Laboratory, Department of Agriculture, London, Ontario.

Its use as a test insect has been restricted because it has been difficult to produce large numbers in the laboratory. A crucial rearing problem is to create conditions that will induce the female to lay eggs.

The most comprehensive work on the cadelle published so far is that of Back and Cotton (1926). These authors gave an account of the history, importance and biology of the insect. However, they did not discuss rearing methods. The object of the present study was to develop a method for producing large numbers of cadelles, uniform in age and origin.

Summary of Life History

The female deposits her small white delicate eggs in clusters in the food, or packs them in crevices of any sort that will offer protection. The number of eggs in each cluster varies from a few to eighty or more, laid daily or at intervals of several days. The young larvae grow well on wheat or graham flour and may complete development in about 54 days. There are usually 4 instars but sometimes a fifth larval moult occurs. Mature larvae bore into wood or some other material and form a pupal cell. The prepupa forms soon after. Pupal development requires 8 to 25 days. The newly formed adult remains in the pupal chamber for at least a week, while its exoskeleton is hardening, and then emerges by chewing a hole through its cell. Complete development from egg to adult may take place in 67 days. The record for adult longevity as recorded by Back and Cotton (1926) was 668 days.

Rearing and Feeding Methods

Adult Feeding

Preliminary investigations showed that the presence of mould in the food stimulated oviposition. During later work the addition of yeast to the food proved to be equally effective. Thus two types of media have been used successfully to feed adults for egg production. They are referred to as the "mouldy oatmeal culture" and the "yeast oatmeal culture".

1. *Mouldy oatmeal culture*: This culture is prepared in quart fruit jars adapted for the purpose. A false bottom is made by gluing a circular piece of plastic screen four inches in diameter to a cylindrical piece of pliable sheet plastic one inch high. This platform holds the medium up from the bottom of the jar and allows excess moisture to drain off. Screen tops on the jars allow air exchange yet prevent contamination by other insects. One hundred and fifty grams of fine oatmeal is poured in the jar and packed down firmly. Seventy-five ml. of water is then poured in so that the central portion of the medium will be soaked while the outside remains dry. Thus the developing mould will grow out from the moist central part to form a solid mass of mycelium throughout. If moisture does seep to the sides of the jar, the medium will soon shrink away from the sides and leave a space in which the adults may be trapped. Adequate mould will grow in two days at 77°F. to make the medium suitable for feeding purposes. Five pairs of adults are sufficient for each jar. The medium must be replaced once every two weeks, otherwise egg production will dwindle and the decaying oatmeal will become disagreeably odorous or dusty.

2. *Yeast oatmeal culture*: This culture is made up in large petri dishes 120 x 20 mm. Oatmeal with 5 per cent brewers yeast moistened with a solution of agar and water serves as the food. Agar is used so that the moisture will be retained longer in the food. Two grams of agar heated in 30 ml. of water will moisten 100 grams of oatmeal yeast to the desired extent. This should be thoroughly mixed so that the moisture is evenly distributed throughout the

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medium. Three grams of food is placed in each petri dish and is sufficient for three pairs of adults. This medium is replaced twice a week so that food of high moisture content will always be available.

Sexing the Adults

Males and females can be easily distinguished by the punctuation of the ventral side of the abdomen. The male punctures are very numerous and some are very fine, while those of the female are less numerous and always coarse. These characters can easily be seen with the binocular microscope on both living and dead specimens using 32 diameters magnification.

Egg Laying

To produce conditions favorable for oviposition it is essential to provide a suitable crevice in which the female can lay her eggs. Such a crevice has been devised and is referred to as the "egg laying block". Two pieces of 3/16 inch thick plastic sheet are cut in one inch squares and two thicknesses of paper ⅜ inch square are glued to the centre of one block. The other block is placed on top of the paper squares and an elastic band is wrapped around both blocks to hold them together. The two blocks are thus held 0.3 mm. apart so that the eggs

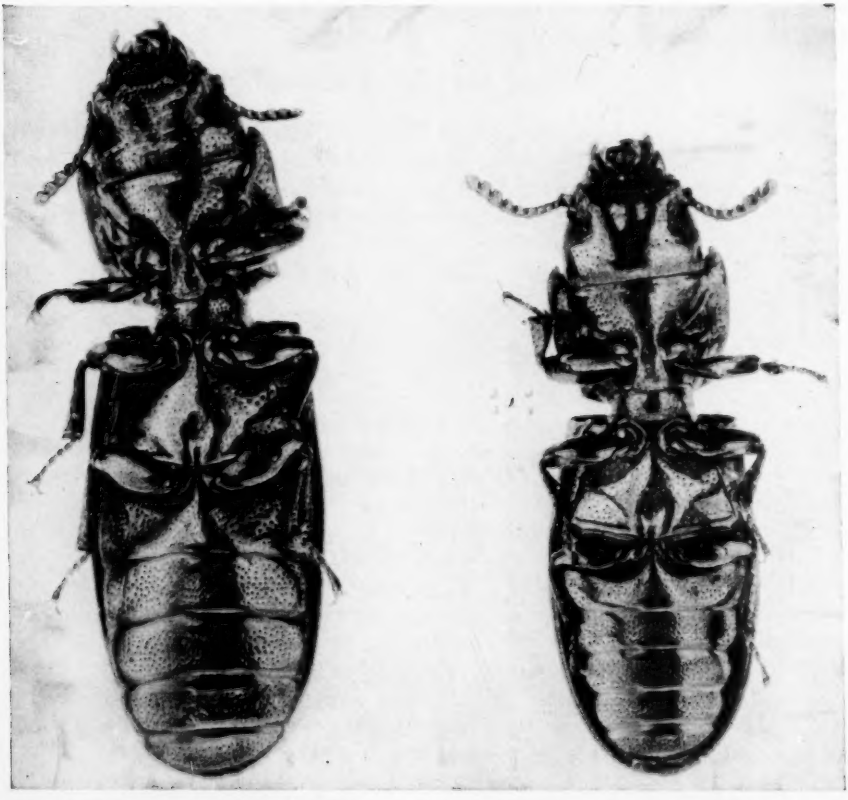

Fig. 1. Ventral view of the female (left) and male (right) cadelle adults showing the sculpture of the abdomen which is used for sex determination.

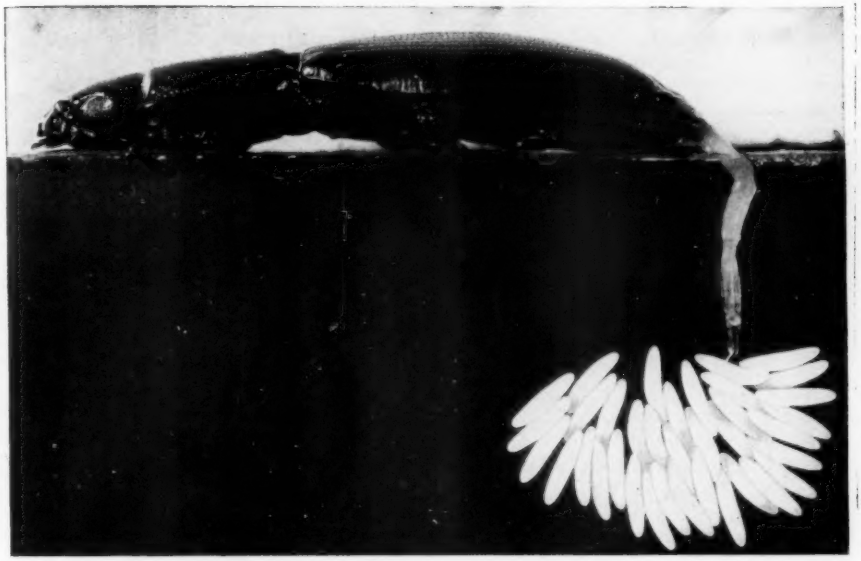

Fig. 2. The female cadelle depositing her eggs in the crevice of the "egg laying block".

which are approximately 0.27 mm. diameter will fit between. This "egg laying block" is then placed on top of the food where it will be accessible to the females. They will deposit the eggs in clusters in the crevice thus provided. The eggs are clearly visible and can be readily counted through the transparent blocks. The clusters can be removed easily by separating the blocks and sliding a sharp scalpel beneath the eggs to lift and slide them off.

The eggs should be removed daily from the egg laying block and may be kept in small petri dishes until they hatch or they may be put directly on the whole wheat flour and allowed to hatch there. If kept in petri dishes the supply of eggs for each day should be kept separate, otherwise larvae hatching from older eggs will eat the unhatched eggs. Under controlled conditions of 77°F. and 70 per cent relative humidity hatching occurs 7 to 8 days after laying.

Both the "mouldy oatmeal culture" and "yeast oatmeal culture" proved to be quite satisfactory for continuous egg production. To determine fecundity and viability from adults kept on mouldy oatmeal, ten pairs of newly emerged adults were placed in separate culture jars and the eggs were collected daily. Table I shows the production records of the females. It can be seen that the total number of eggs produced by each female varied greatly, also there was considerable variation in the numbers laid from day to day. By this method a maximum of 3,581 eggs were recovered from one female. This is approximately three times as many eggs from one female as reported by Back and Cotton (1926). Table I shows that, except for the complete failure of the eggs from female No. 3, the per cent hatch varied from 57.8 to 76.9 per cent. However, one hundred per cent hatch was recorded on some days and it was not uncommon for over 90 per cent of the eggs to be fertile.

After females started to lay they often continued to produce eggs every day for some time. As they became older and approached the end of the oviposition

TABLE I

Egg-laying Performance of Ten Females Reared on Mouldy Oatmeal Cultures, One Female and One Male to each Culture

Female No.	Preoviposition Period (days)	Total No. of Eggs Laid	Per Cent Hatch	Total Length of Egg-laying Period (days)	Life Span of female
1	11	605	74.8	40	77
2	10	3,191	61.9	193	213
3	30	72	0	5	112
4	13	439	76.7	14	49
5	16	3,422	59.3	70	86
6		0			33
7	12	3,096	76.9	163	332
8	15	1,581	76.4	65	85
9	13	2,441	57.8	155	179
10	11	3,581	72.1	152	218

period they laid less frequently but the number laid in each cluster was approximately the same for each female, and appeared to be characteristic of each individual.

Larval Rearing

Whole wheat flour was found to be a suitable medium for rearing larvae. It allows rapid and uniform development, and larvae are easily removed from it by sifting. Other foods tested, but found to be less satisfactory were: oatmeal, corn meal, pablum, klim (powdered whole milk), Gaines dog meal, whole peanuts, wheat germ cereal, whole wheat, all purpose wheat flour, pig starter, and a diet consisting of corn meal 4 parts by weight, whole wheat flour 2 parts, klim 2 parts and dried brewers yeast 1 part (Haydak, 1943).

TABLE II

Number of Larvae and Adults Developing to Maturity when reared on Whole Wheat Flour. One Hundred Newly Hatched Larvae were started on Each Jar

Jar. No.	No. Mature Larvae Recovered	No. Adults Recovered
1	92	69
2	82	69
3	93	78
4	80	60
5	74	49
6	88	69
Per Cent Development	84.8	65.7

As shown in Table II, 84.9 per cent of the larvae started on whole wheat flour developed to the mature fourth instar stage and 65.7 per cent developed to the adult stage. One hundred newly hatched larvae were put on 250 grams of the whole wheat flour in quart jars with screen tops. These jars were then placed on shelves in the rearing room and the larvae left to develop. They grew to maturity in eight weeks.

Pupal Development

Coarse building cork serves as a refuge into which mature larvae can bore to pupate. It is cut in half inch cubes and placed on top of the flour in the larval rearing jars. The larvae work their way to the surface of the flour, bore into the cork and excavate the pupal cell. Prepupae are usually formed soon after this cell is made. However, some individuals may remain as larvae for several weeks after boring into the cork. Development through to the adult stage continues uninterrupted once the prepupa has formed and requires ten to twenty days.

Male and female pupae can be distinguished by the characters of the genitalia on the ventral side of the abdomen. On the female the gonopods are present as two lobes, one on each side of the genital pore while no gonopods can be seen on the male.

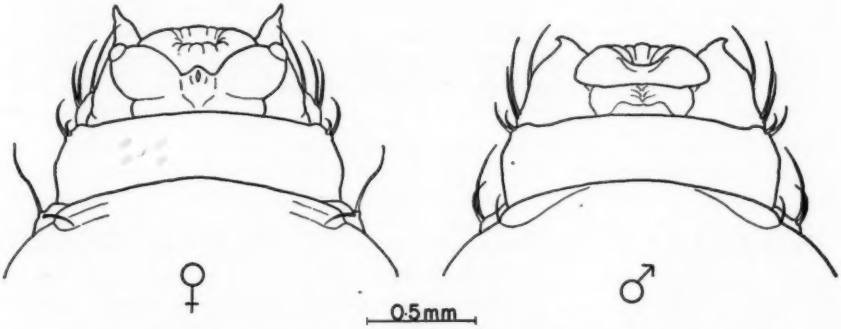

Fig. 3. Ventral view of the terminal segments of the abdomen of cadelle pupae.

Summary

1. Methods have been developed for rearing and handling all stages of the cadelle.
2. The crucial rearing problem is to create conditions that will induce the female to lay eggs. High egg production has been obtained through the use of two types of media for adult feeding. These are referred to as the "mouldy oatmeal culture" and the "yeast oatmeal culture".
3. The female cadelle prefers to deposit her eggs in small crevices. A suitable site was made by placing two squares of plastic one above the other with a thin spacer of paper between them. The female placed her eggs in clusters in the crevice thus provided. The eggs were easily observed and removed for rearing purposes.
4. Larvae develop rapidly and uniformly on whole wheat flour. They reach maturity in eight weeks when reared on this medium and kept at 77°F. and 70 per cent relative humidity.
5. A method for sexing adults and pupae is given.

6. By these methods one pair of adults have produced a maximum of 3,581 eggs and 72.1 per cent of these were viable. According to results obtained from larvae reared on whole wheat flour it would have been theoretically possible to obtain from such a pair approximately 2,190 mature larvae and 1,700 adults.

Acknowledgments

This study was started at the Fumigation Station, Plant Protection Division, Montreal, P.Q., and completed at the Science Service Laboratory, London, Ontario. During the development of the program, valuable technical assistance was afforded by Miss G. P. Waterston and Mr. E. Upitis of the London Laboratory, and by Mr. J. E. King of Montreal. Thanks are due to Mr. John Gates of this laboratory for the photographic work. Characters for sexing the adults were determined by Mr. W. Brown of the Systematic Unit of the Division of Entomology. Dr. W. W. Judd, University of Western Ontario, identified the structures used for sexing the pupae.

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Parasitic Flies of the Genus *Prosenoides* (Tachinidae, Diptera)[1]

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The present genus includes both neotropical and nearctic species of which none appears to have been encountered commonly in either economic or faunistic investigations. In the material available for the present study, only two or three species, including *curvirostris* (genotype) are represented in good series. A critical study of the accumulated material has disclosed a number of hitherto unknown species, the descriptions of which are presented below.

Prosenoides was founded by Brauer and Bergenstamm (Zweifl. Kaiserl. Mus., V, 1891, 370) for a supposed new species, *papilio*, from Brasil (*Prosena curvirostris* Bigot) from Mexico (Annales, 1888, 264). Notes recently taken on the type of the latter in the British Museum were made available for the purpose of this review by Curtis Sabrosky, to whom I am also under obligation for the loan of pertinent material in his charge. All types based upon the latter are returned to the U.S. National Museum.

The genus *Prosenoides* differs from *Prosena* chiefly in having the propleura setose, palpi slender and about as long as the antennae. Besides these items, *Prosenoides* possesses the following peculiar characters: Proboscis setiform reaching to or beyond middle of venter, haustellum usually bowed forward or upwards, labella slender; clypeus deeply impressed at sides, facial carina strong separating

[1]Contribution No. 1961, from Department of Entomology, Texas Agricultural Experiment Station

bases of antennae and extending to epistoma; facialia bare; arista plumose to tip; frontal bristles stopping at antennal base; eyes bare; legs slender, tarsi greatly exceeding tibial length.

As here considered, the present genus includes eight species which are all included in the accompanying key. The members are quite uniform with respect to genital structures, thoracic chaetotaxy and most other external items except perhaps color pattern and some minor differences in bristling of the legs and abdomen. To avoid repetition of details under the following specific descriptions, the items which apply to the members in common are summarized for immediate reference as follows:

Head wider than high, frontal profile distinctly longer than facial; antennal axis near eye middle and subequal to oral; epistoma slightly prolonged downward and forward, almost equal to clypeal width; vibrissae distinctly above oral margin; male front at vertex a trifle wider than ocellar triangle and about one-third the head width in female; latter with one smaller reclinate and two stouter proclinate orbital bristles; ocellars proclinate, often three or more secondary pairs especially in male; frontal bristles in a single row extending from anterior margin of ocellar triangle to near antennal base; antenna rather slender but distinctly shorter than face, third segment three or four times length of second; arista about equal to combined length of last two antennal segments, slightly thickened on basal fourth or less, proximal segments short; parafacial bare or nearly so, not narrowed downward; cheek bare on upper part and with only sparse pale hairs below; back of head flattened, gray pollinose, with pale hairs about the neck and on lower margin.

Thorax and scutellum black, usually rather densely pollinose, mesonotum distinctly vittate. Chaetotaxy: acrostichal 1, 2 or 3 (none near suture); dorsocentral 3,3; intraalar 2 (none immediately behind suture); supraalar 3; presutural 1 (outer); notopleural 2; posthumeral 2; humeral 3-5; postalar 2; steropleural 3; pteropleural 1 (not very large); scutellum with 2 lateral, 1 smaller decussate apical and usually 1 or more pairs of weakly differentiated appressed discals behind middle; prosternum and postnotum beneath calypters bare. Legs long and slender (tarsi especially so or about one-half longer than corresponding tibiae), weakly bristled; hind tibia not ciliated; claws and pulvilli usually short in both sexes. Wing subhyaline, extending well beyond tip of abdomen; first vein bare, third with 2 to 5 hairs near base; first posterior cell narrowly open about length of small cross vein before extreme wing tip; hind and apical cross veins oblique and in same plane; cubitulus without stump or fold, obtusely rounded near hind margin of wing; last section of fifth vein short; costal spine vestigial; calypters about as wide as long; epaulet infuscated.

Abdomen narrower and tapered apically in male, broader and ovate in female, mostly pollinose above; no discals on any segment but a complete marginal row of strong erect bristles on last two and a median marginal pair on second segment, latter sometimes weak and hardly differentiated; sternites covered; male genitalia caudoventral, not wholly retracted in repose; forceps small and soft in texture, tapering apically and divided beyond middle, prongs delicate; accessory process very broad or platelike at base terminating in a blunt evenly rounded shining brown tip; penis simple, jointed near middle, the slender acute-tipped distal segment slightly bowed forward in profile; female genitalia not adapted for piercing.

Key to Species of *Prosenoides*

1. Median marginal bristles on second abdominal segment well developed and usually erect 4
   Median marginals on second abdominal segment weak and appressed (at times scarcely larger than the surrounding hairs) 2
2. Fore tibia with one posterolateral bristle 3
   Fore tibia with two posterolateral bristles; parafrontal, parafacial and cheek golden pollinose; cheek nearly one-half eye height; legs black, female only (Guatemala) ..... *diacrita*, n. sp.
3. Legs black or predominantly so; mesothoracic spiracle dark brown to black; haustellum entirely black; abdominal pollen usually tinged with yellow on upper surface (Mexico, Central and South America) ..... *curvirostris* (Bigot).
   Legs yellow (tarsi blackish); mesothoracic spiracle pale yellow; haustellum yellowish latero-basally; abdomen gray pollinose (Georgia, Forida, Cuba) ..... *flavipes* Coquillett
4. Fore tibia with one submedian posterolateral bristle 5
   Fore tibia with two posterolateral bristles; haustellum reaching almost to apex of abdomen; femora and tibiae in part or wholly reddish; abdomen yellowish gray pollinose (Brasil to Argentina) ..... *haustellata* (Townsend)
5. Legs black or predominantly so 6
   Legs except tarsi wholly yellow; abdomen gray pollinose; calypters glassy white ..... *flavipes* Coquillett
6. Parafacial golden pollinose 8
   Parafacial gray or cinereous 7
7. Antenna wholly yellow; thoracic vittae broader approximating width of intermediate pollen stripes; abdomen gray pollinose with three brownish vittae above on intermediate segments, male only (Argentina, Paraguay) ..... *trilineata*, n. sp.
   Antenna not entirely yellow, third segment black or at least infuscated apically; dark thoracic vittae narrower than intermediate pollen stripes; abdomen with patternless gray pollen, at times showing a poorly defined dark median vitta on intermediate segments (U.S., Mexico) ..... *assimilis*, n. sp.
8. First abdominal segment with a pair of median marginal bristles (appressed and usually hairlike in female); parafrontal black-haired outside of frontal row; male claws and pulvilli shorter than last tarsal segment; female with three irregular rows of black hairs behind eye above (Arizona, Mexico) ..... *grandis*, n. sp.
   First abdominal segment without median marginals; parafrontal practically bare outside of main frontal row; male claws and pulvilli strikingly elongated, exceeding the combined length of last two tarsal segments; female with only two rows of black hairs behind eye above (Argentina) ..... *isodomos*, n. sp.

Prosenoides curvirostris (Bigot)

Prosena curvirostris Bigot, Annales, 1888, 264.—Aldrich, Cat. N. A. Dipt., 1905, 496.
Prosenoides papilio Brauer and Bergenstamm, Zweifl. Kaiserl. Mus., 5, 1891, 370; Ibid., 6, 1893, 175.—Townsend, Manual of Myiology Part 3, 1936, 136; Ibid., Part 7, 1938, 368.

Male and female.—Parafrontal, face and cheek silvery white pollinose on pale background; frontalia reddish to yellow, narrowed upwards but equal to or exceeding parafrontal width; latter practically bare outside frontal row; antenna yellow, third segment usually infuscate on apical half or more; parafacial bare, narrower than epistoma, eye reaching to vibrissal level; occiput above with one row of black hairs behind occipital fringe. Thorax densely gray pollinose, with three well defined black dorsal vittae; mesonotal and pleural vestiture black. Abdomen wholly black in female, but broadly reddish to brown on sides in male, entire upper surface dusted with pale gray patternless pollen which shows a vague narrow interrupted median vitta in well preserved specimens; median marginals and hairs on second segment appressed. Legs largely blackish; claws short and strongly curved. Wing clear with a slight yellow tint on costal half; veins yellow including costa; calypters tawny translucent. Length 5-9 mm.

A rather variable species which ranges southward from Mexico through Central America to Ecuador, Peru and Brasil. None of the material examined, which includes 24 specimens in the U.S. National Museum besides a pair in my

collection, is accompanied by any rearing data. The type series is in the British Museum.

***Prosenoides diacrita*, n.sp.**

Female.—This species, like the genotype, bears a pair of weak appressed median marginals on each of the first two abdominal segments. It differs, however, in a number of items as enumerated in the accompanying key to species. The unique female has wider cheeks than any of the allied forms; head densely golden pollinose on pale background, clypeus and occiput cinereous; antenna black, proximal segments dark reddish to brown; palpus moderately thickened apically and barely exceeding antennal length; parafacial bare, nearly as wide as epistoma; thoracic pollen faintly yellowish on mesonotum, pleura cinereous; legs black, tarsi very long and slender; claws short and strongly bowed, pulvilli minute; calypters whitish with a slight yellowish tinge. Length, 6 mm.

Holotype female, S. Cristobal, Guatemala, Alta Vera Paz, May 17, 1926 (J. M. Aldrich), in the U.S. National Museum.

***Prosenoides flavipes* Coquillett**

Prosenoides flavipes Coquillett, Proc. Acad. Nat. Sci. Phil., 1895, 314-315.—Aldrich, Cat. N. A. Dipt., 1905, 497.—Fattig, Emory Univ. Mus. Bul., 8, 1949, 28.

Male and female.—The predominantly yellow legs distinguish this species from its congeners. Other salient items may be briefly listed as follows: Head silvery pollinose on pale background occiput above somewhat darker with lusterless gray pollen; parafacial bare; proboscis slender, reaching to mid-venter, haustellum yellowish on sides near base; male antennae wholly bright yellow but third segment more or less infuscated in female; prothoracic spiracle fringed with pale yellow hairs; epaulet reddish basally; calypters transparent white; abdomen gray pollinose, broadly reddish on sides of three basal segments in male and wholly black in female; median marginals on second segment more or less appressed but usually well differentiated; otherwise as in *assimilis*. Length, 6-7.5 mm.

The type series of *flavipes*, which I have not seen, is in the U.S. National Museum. Hitherto, the species has been recorded only from Georgia, Florida and Cuba; nothing is known concerning host relationships.

***Prosenoides haustellata* (Townsend)**

Neoprosena haustellata Townsend, Gen. Musc. Hum. Trop. Am., 1926, 221, 335; Manual of Myiology, pt. 7, 1938, 352-353.

Male and female.—Darker or more brownish in general aspect than most allied forms; parafrontal and parafacial yellowish gray pollinose on dark background; frontalia blackish, narrowed upwards but subequal (female) to wider (male) than parafrontal on entire length; antenna reddish yellow to level with arista, remainder of third segment black; parafacial fully one-half clypeal width, apparently bare but with a few very minute or inconspicuous setae perceptible under magnification; cheek under one-third eye height; proboscis curved forward but long enough to reach almost to ventral apex of abdomen; thorax dusted with rather heavy yellowish gray pollen above, pleura paler or grayish; notum marked with five narrow but well defined dark vittae; wing reaching well beyond tip of abdomen, with a rather uniform yellowish tint except on posterior margin in male; calypters transparent tawny; legs long and slender, femora and tibiae largely or wholly reddish (female) but distinctly infuscated apically (male), tarsi blackish; abdomen entirely yellowish gray pollinose above, median marginals on second segment stout and erect; male hypopygidum blackish, first segment pollinose

above, fifth sternite with a broad V-shaped apical excision, lobes blackish bearing a few slender black hairs on inner margin; female anal orifice smallish and rounded, genitalia retracted in repose. Length, 5.5-6.5 mm.

This neotropical form, designated the type of *Neoprosena,* clearly falls within the generic limits of *Prosenoides* as here limited. The type series is in the U.S. National Museum. I have not seen it. Material examined includes six males and four females mostly collected by Dr. C. H. T. Townsend labelled Itaquaquecetuba, Sao Paulo, Brasil. One female in my collection is from Villarica, Paraguay.

***Prosenoides assimilis*, n.sp.**

This is perhaps the most common nearctic member of the genus. The principal items which distinguish it from the preceding species are listed in the accompanying key.

Male and female.—Head pale subsilvery pollinose, occiput darker ashy or gray; frontalia pale yellow to deep brown, narrowed upwards; antenna blackish, proximal segments including base of third more or less reddish; parafrontal with only a few black hairs outside frontal row; parafacial apparently bare, but sometimes with scattered small inconspicuous hairs on lower half; palpus yellow, slender or slightly thickened apically in female; haustellum about twice head height. Thoracic dorsum and scutellum with rather heavy opaque gray pollen; three to five mesonotal vittae, middle one on each side linear before suture to shortly behind, outer pair heavy but in some views apparently interrupted at suture. Abdomen wholly black in both sexes, with rather dense lusterless gray pollen on entire upper surface, which may show a slight yellowish tinge in the female; median marginals on second segment always stoutish and usually erect, the corresponding pair on first segment weaker and depressed (frequently absent in female). Wing as in *curvirostris.* Tibiae with an apparent reddish tinge in ground color. Length, 5-9 mm.

Holotype male and allotype female, College Station, Texas, April 29, 1947 and May 2, 1943 (H. J. Reinhard) in the U.S. National Museum. Paratypes: 23 males and 33 females, same locality as type, April 18 to November 7 (H. J. Reinhard); 2 males and 2 females, Hidalgo Co., Texas, July and August, no collector's label; 1 male, Kerrville, Texas, April 12, 1907 (F. C. Pratt); 1 female, Bexar Co., Texas, September 26, 1931 (H. J. Reinhard); 1 female, Eagle Pass, Texas, November 28, 1907 (J. D. Mitchell); 1 female, Marathon, Texas, April 23, 1922 (C. S. Rude); 1 male, White Mts., Rio Ruidoso, abt. 6000 ft., New Mexico, July 30 (C. H. T. Townsend); 1 female, Beulah, New Mexico, 8000 ft., August (Cockerell); 4 males and 1 female, Ft. Ancient, Ohio, June 10-12, 1902, J. M. Aldrich Collection; 1 female, Pueblo Viejo, Veracruz, Mexico, December 8, 1909 (F. C. Bishopp); and 1 female, "Chapalilla, Nay., Mex., July 19, 1951, Baccharis, P. D. Hurd".

***Prosenoides trilineata*, n.sp.**

Male and female.—This segregate may eventually prove only a color phase of the preceding species. In the limited material available for study, the uniformly bright yellow antennae and the abdominal pollen pattern, as mentioned in the foregoing key, seem distinctive especially in the male. Also, in the latter the mesonotal vittae are apparently heavier and more defined than in *assimilis.* Two females from the general type locality seemingly belong here; the antennae in both have the same unusual bright yellow color, but the abdomen is more extensively pollinose with only a median vitta apparent. Length, 7 mm.

Holotype male, Tucuman, Argentina, October 15, 1928 (H. A. Jaynes) and paratypes as follows: 1 male, same data as type; 1 female, Santiago de Estera, Argentina, May 22, 1927, Kisliuk 711; and 1 female, "Sapucay, Paraguay, 7.5, 1902", all in the U.S. National Museum; and 3 males, Villarica, Paraguay, September, 1937 (F. Schade) in my collection.

***Prosenoides grandis*, n.sp.**

Male and female.—Sides of front and face including upper part of carina, broad cheek groove and posterior orbit golden pollinose; clypeus at sides, lower half of cheek and occiput cinereous or ashy gray; antenna black, apex of second segment and base of third more or less reddish; parafrontal clothed with black hairs (more thickly so in male) outside frontal row; parafacial subequal to width of epistoma, with short sparse or scattered hairs below middle; palpus slender to tip, beset with black hairs, some bristly near apex; haustellum length a little under twice head height. Thorax rather densely gray pollinose, three mesonotal vittae behind suture and five before, of the latter the intermediate pair is quite linear and appears best defined in a flat rear view; abdomen wholly black, with gray pollen in a tessellated pattern; hairs rather long and erect in male; median marginals on first segment, depressed, usually weak and barely differentiated in female. Wing gray hyaline, veins brown to blackish; calypters semitransparent white, sometimes with a slight smoky tinge at middle. Length, 7.5-10.5 mm.

Holotype male and allotype female, Chiricahua Mts., Arizona, July 20, 1950 (R. H. and L. D. Beamer) in the Snow Entomological Collection, University of Kansas. Paratypes: 10 males and 3 females, same data as type, including additional collectors (H. O. Wright, Paul P. Cook, W. J. Arnold); 1 male, same locality, 9000 ft., July 20, 1950 (F. Werner and W. Nutting); and 1 male, labelled "Sierra Madre, Chih. Mex., HdR Piedras Verdes abt. 7300 ft., on flowers of Rhus glabra, Coll. Townsend", in the U.S. National Museum.

***Prosenoides isodomos*, n.sp.**

Male and female.—With the general habitus of *grandis* but at once distinguished by the items listed in the preceding key. Some additional minor differences may be pointed out as follows: cheek and parafacial more distinctly golden, latter bare and a little narrower than epistoma; thorax trivittate; male calypters distinctly infuscated and the abdominal hairs depressed. Length, 9.5-11 mm.

Holotype male and allotype female, Tucuman, Argentina, March 25, 1930 (H. A. Jaynes) in the U.S. National Museum.

This is the only known member of the genus in which the male possesses greatly elongated claws and pulvilli.

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Occurrence of Adults of the Carrot Rust Fly, *Psila rosae* (Fab.) (Diptera: Psilidae), on Corn Foliage at Bradford, Ontario[1]

By JANE B. WILLIAMS[2]

Adults of the carrot rust fly, *Psila rosae* (Fab.), are difficult to find in the field. Frequently they can be found in light to moderate numbers in some situations, occasionally in large numbers, rarely in moderate to large numbers over a period of several days. Fabricius (1794, p. 356) reported that they were found commonly on flowers in Kiel[3], Germany. Curtis (1860, p. 405) wrote, "The fly . . . was named *rosae* by Fabricius, being found probably sunning itself upon the leaves of rose bushes". Several British writers observed that the flies were most numerous in the parts of carrot fields sheltered by hedges. Baker *et al.* (1942) wrote: "Flies were present in small numbers on certain weeds, but in considerable numbers in the hawthorn hedges". Roebuck (1945), Wilson (1945), Petherbridge *et al.* (1945), and Wright *et al.* (1945) made similar observations. Some British writers reported flies on various plants, as follows: Whitehead (1890), on low shrubs near streams and in meadows; Smith (1921), on sallow, oak, and hazel; Petherbridge *et al.* (1942, 1943, 1945), on wild chervil (*Anthriscus sylvestris*), hemlock (*Conium maculatum*), nettles, and potatoes; Wilson (1945), on coarse herbage, growing crops (especially potato), weeds (especially nettles); and Wright *et al.* (1946), on trees, hedges, and ditches with a thick herb covering.

Few writers are definite about the length of time flies were observed in one situation. In many references time is not mentioned; in others, the time involved was obviously short, not more than a day or two. Fabricius said that adults were found commonly on flowers; Whitehead, that they were "found in the spring upon the leaves of low shrubs, near streams and in meadows". Both suggest the long-term presence of the insect in these situations. Baker *et al.* stated, "The flies remain assembled in large numbers in the hedges surrounding the previous year's crop for a considerable period of time".

In 1952, at Bradford, Ontario, flies were observed in large numbers on corn foliage during a period of 34 days. The corn was growing in a single row about 30 feet long, broken midway by a path. Study plots of carrots, about an acre in size, were growing to the immediate south. The field was near the north canal bank of the Bradford marsh. The bank is about 15 feet high, and the bottom of the canal is several feet above the level of the cultivated land. The purpose of the canal is one of drainage rather than of irrigation. In this area, injury to carrots and celery is usually severe. However, in 1952, flies of the overwintered generation were scarce, and first-generation larval injury to carrots was extremely light. First-generation flies were also scarce until they were seen on the corn foliage.

Flies were present on the corn from August 12 to September 15. Only five flies were seen on the adjacent carrots, and these from July 30 to August 27. The peak of abundance on the corn was on September 5, when 68 flies were counted. From August 12 to 31, flies were moderately abundant; about 20 to 30 could be

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3Contrary to popular belief on this continent, the city that Fabricius called *Kilia* was Kiel, Germany, not Kilia, Bessarabia. *Kilia* was merely a latinized form of *Kiel*; other latinized forms he used were *Chilonius* and *Kilonius*. Later writers misinterpreted the location of the city. According to Professor Tuxen (in litt.), University Zoological Museum, Copenhagen, who is familiar with Fabricius' collections, Fabricius undoubtedly meant Kiel, Germany; it is significant that Fabricius was for many years on the staff of the Kiel Academy; apparently he never visited Bessarabia.

counted on the north side of the row from about 7.30 p.m. to 8.15 p.m. (all times given are daylight saving time). From September 1 to 3 they were scarce. On September 4, 60 were counted; and on September 5, 68, of which 18 were on one plant. From September 6 to 10, the flies were moderately abundant. After hot days from September 10 to 15, they became scarcer, and on September 15 one fly was seen on the corn.

No flies were seen on any other corn on the marsh. Corn is not a commercial crop in the area, but some growers plant a single row for home use. Corn was examined on four farms; in one case a single row was growing next a carrot field.

From August 12 to September 15, hourly observations on the activities of the flies on the corn, and of weather conditions, were made daily. The flies varied in abundance during the day, being scarce during the hottest and windiest periods. They were moderately abundant from 9 to 10.30 a.m., gradually decreasing in numbers from 10.30 to noon, and were scarce from noon until about 5.30 p.m.; from 5.30 to 7.30 p.m. they reappeared and were most abundant from 7.30 to 8.15 p.m., from shortly before until about half an hour after sunset. The flies appeared to seek shelter from wind and sun. They were almost always more abundant on the north side of the corn row. The row ran east and west, so that the north side faced away from the sun; the canal bank also ran east and west, sheltering the north side of the row from the wind. From about 11 a.m. to 5 p.m. on sunny days, most of the flies were found on the lower surfaces of the corn leaves. At other times, and on cloudy days, they were seen on both leaf surfaces.

It was not discovered where the flies went when they were not on the corn. Never more than a few flies were found elsewhere. They did not appear to increase in abundance in the carrot field, though many flies must have visited the carrots at some time, for a severe infestation by first-generation larvae developed. Possibly the female flies visited the carrots a few at a time to lay eggs; perhaps the male flies never did enter the carrot fields.

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Concerning *Tomotaenia* and *Paraplanes*, with the Description of a New Dignathodontid Centipede from Missouri (Chilopoda: Geophilomorpha: Dignathodontidae)

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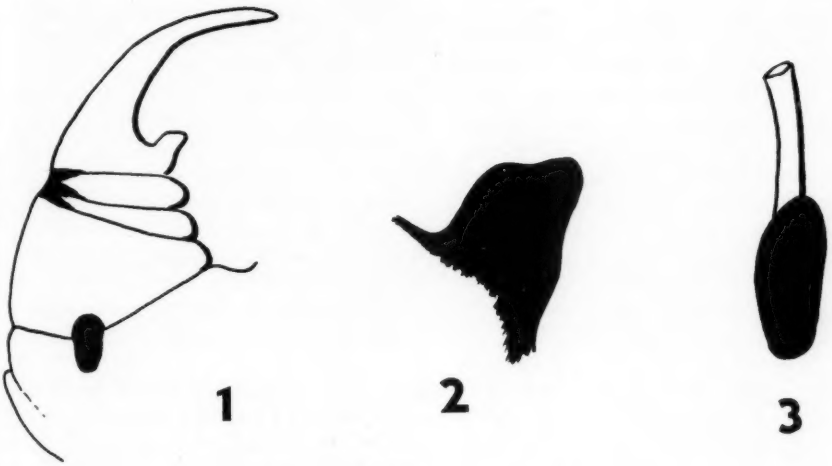
Tomotaenia was proposed in 1895 by O. F. Cook (3, p. 866) for the reception of a number of Nearctic species; *Strigamia parviceps* Wood, 1862 (6, p. 49) was cited as the genotype. In 1953 (4, p. 172) I considered *Tomotaenia* a junior synonym of *Strigamia* chiefly because reliable information on the questionable type species, *parviceps*, was neither to be gained from a study of the unavailable type specimen nor from a perusal of the literature and because of the fact that the original description of *parviceps* in some ways suggests the typical *Strigamia* habitus. In addition, Attems and others have placed *parviceps* in *Scolioplanes* [=*Strigamia*]. However, in a paper recently published Chamberlin (2) shows that dignathodontid [linotaeniid of Chamberlin] centipedes agreeing in many particulars with Wood's descriptions of *parviceps* and especially *epileptica* (loc. cit) inhabit the northwestern United States in some abundance. Perhaps the most striking characteristics of these specimens are their possession of undivided ultimate pedal pretergites, broad ultimate pedal sternites, and coxopleural pores restricted to an area immediately bordering the afore-mentioned sternites. These features, then, might be taken as justifiable bases for separating forms *congeneric with epileptica* from those properly referable to *Strigamia*.

I emphasize *epileptica* in this connection because its holotype is preserved in the Academy of Natural Sciences at Philadelphia, and, in fact, Chamberlin has recently studied and redescribed it in his 1954 paper. But it is most important to note that the holotypical specimen of *parviceps*, upon whose name and nature the generic name *Tomotaenia* rests, is unavailable; hence we can only *postulate* the congenericity of *parviceps* with the newly-known *epileptica*. Perhaps from a more practical standpoint this point might be discounted almost without comment except that on the basis of Wood's 1862 original description of *parviceps* the generic identity of his specimen should be held in some question. Following the formal characterization Wood wrote: "In the only specimen that we have seen the mandibles [prehensors] are perfect, with the exception that they lack the mandibular tooth [tarsungular basal tooth?], probably the result of an accident; but it is rather curious that *both should be lost* [italics mine] and the remainder of mandibles [sic] be uninjured." Thus there remains the possibility, if we interpret his terminology correctly, that Wood might have been dealing with something akin to *Agathobius* Bollman, 1893, whose single species, *gracilis*, is distinctive in lacking precisely these basal teeth. At the same time his observation may have been occasioned by poor magnifying equipment or, as he suggests, by a bizarre accident. In summary, my own present inclination is to follow Chamberlin's arrangement, in its essentials, provisionally but to hold it subject to question and revision should further evidence show *parviceps not* to be zoologically congeneric with *epileptica* and its congeners.

In the same paper Chamberlin placed *Paraplanes* Verhoeff, 1934 (5, p. 22) in synonymy under *Tomotaenia*. This action must have been based upon the premise that the west coastal *P. californicus* Verhoeff, 1938 is congeneric with the type of the genus, the Asiatic *P. svenhedini* Verhoeff, 1934. Consequently it should be emphasized that *Paraplanes* can only be considered a subjective synonym of *Tomotaenia*, in fact a doubly-subjective synonym in the light of the



Tomotaenia (*Korynia*) *urania* sp. n.

1, right prehensor (ventral aspect); 2, basal tooth of right prehensor; 3, poison calyx with portion of duct from right prehensor (ventral aspect).

questionable identity of *parviceps* at the present time. The crucial question here, it seems to me, is bound up with the characteristics of *svenhedini* and perhaps specifically with the nature of its ultimate pedal pretergite (whether it is laterally divided or not). Unfortunately Verhoeff failed to mention this important criterion. Consequently if it can be shown that the ultimate pedal pretergite of Verhoeff's holotype is undivided, I would be inclined to view *epileptica* and *svenhedini* as consubgeneric; on the other hand if the future shows the tergite to be laterally suturate, according to the arrangement that follows, I would consider placing the Verhoeff species in *Korynia* Chamberlin, 1941 (1, p. 774). The following key will indicate my present suspicions concerning the relationships of the dignathodontid genera represented in the area east of the Rocky Mountains.

A-1. Tarsungula without a basal tooth ..... *Agathothus* Bollman
A-2. Tarsungula with a pronounced basal tooth.
  B-1. Coxopleural pores exposed and lying along the ultimate pedal sternite or concealed by the overlapping ultimate pedal sternite ..... *Tomotaenia* Cook
    C-1. Ultimate pedal pretergite fused with its pleurites, not bilaterally impressed with longitudinal sutures ..... *T.* (*Tomotaenia*) Cook
    [a provisional interpretation based upon the postulated nature of *parviceps*]
    C-2. Ultimate pedal pretergite separated from its pleurites by longitudinal sutures ..... *T.* (*Korynia*) Chamberlin
  B-2. Coxopleural pores freely dispersed over at least the ventral surface of each ultimate pedal coxopleuron, not concentrated along sternite margin, the majority not concealed beneath sternite ..... *Strigamia* Gray
    D-1. Ultimate pedal pretergite separated from its pleurites by longitudinal sutures ..... *S.* (*Strigamia*) Gray
    D-2. Ultimate pedal pretergite fused with its pleurites ... *S.* (*Linotaenia*) C. L. Koch

Apparently most closely related to the Texan *texensis* (Chamberlin), the present new species differs in the following particulars: cephalic plate with a distinct frontal suture (absent in *texensis*); ventral pores present at least on the

more anterior sternites (undetected in *texensis*); coxopleural pores eight or nine on each side (two on each side in *texensis*); the female has 59 pairs of legs (55 pairs of legs are ascribed to the female holotype of *texensis*).

The difference between 55 and 59 pairs of leg is almost surely insignificant, for many members of the one species may very well evidence pedal counts observed in members of the other species. In general I have found in the Geophilidae and Dignathodontidae a distinct tendency toward increasing intraspecific variability of pedal count as the pedal count modal value increases. Thus a hypothetical form with a pedal count modal value at, say, 35 might show variation from 33 to 37, whereas a species with a modal value at 65 might demonstrate a pedal variation of from 55 to 75. In short, there seems to be a greater pedal dispersion flanking higher modal values. The apparent absence of pore fields in *texensis* seems unlikely; those of *urania*, although obscure, are decidedly present. *Tomotaenia* (*Korynia*) *urania* sp. n.

Type. ♀; Beaumont Boy Scout Reservation (approximately 23 miles west of St. Louis, 5 miles west of Valley Park and 2 miles east of Eureka), St. Louis county, Missouri. October 18, 1936. (Dr. E. P. Meiners, collector). In author's collection, C-1764, with slides 677 and 678.

Total Length: 35 mm. Antennae: 1.5 mm long; fulvous; basal articles contiguous; articles two through four markedly compressed, by contrast remaining articles essentially cylindrical; compressed articles subdensely setose. *Cephalic plate*: 0.5 mm. long, 0.5 mm. at greatest width; narrowing anteriorly, sides gently bowed outward; dilute fulvous; traversed by a pronounced frontal suture. *Clypeus*: at least in part coarsely areolate (consolidated areas not detected); with four preclypeal setae. *Labrum:* greatly distorted due to age of specimen; sidepieces evidently strongly sclerotized; midpiece weakly sclerotized, its fimbriae delicate, hyaline. *First maxillae*: telopodite distinctly bipartite; telepodite and syncoxite lappets apparently absent. *Second maxillae*: bridge-piece hyaline, areolate; telopodite first and second articles without long typical setae but with a few very short blunt setae, third article with about a dozen long typical setae; apical claw unguiform, strongly sclerotized, not tuberculate. *Prehensors*: without chitin-lines; tarsungula evenly acuminate (fig. 1), elliptical in cross-section, not blade-like; basal tooth apically angularly blunt or subtruncate (fig. 2), not conical, not acute, not smoothly thumbshaped; poison calyx roughly oval in outline, relatively short (fig. 3).

Sternites: sordid white; very sparsely setose; those of anterior body third each with a deep medial sulcus; a pair of obscure posteriorly-lying pore fields traced on sternites one through twenty-four (pore fields may occur on sternites posterior to the twenty-fourth but the condition of the specimen precludes their confirmation); ultimate pedal sternite very broad, subtriangular. *Legs:* ventrally sordid white, dorsally sordid yellow; very sparsely setose; ultimate legs no longer than penults, ultimate apical claw conspicuously shorter and less robust than that of penultimate leg. *Coxopleuron:* markedly inflated; pores all large and concealed completely beneath edge of ultimate pedal sternite, nine pores on left, eight pores on right coxopleuron. *Tergites:* smoothly areolate, burnished, on anterior body third; coarsely areolate, centrally whitish-yellow, laterally sordid yellow on remaining two-thirds of body; ultimate pedal pretergite impressed on each side with a longitudinal suture so that the pleurites may be said to be separated or free; all tergites virtually glabrous. *Pleurites:* pale whitish-yellow; practically glabrous; spiracles round or nearly so, none distinctly elliptical.

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Un nouveau *Somatochlora* subarctique (Odonates, Corduliidae)

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Cette espèce a été obtenue au cours d'une exploration entomologique[1] de l'auteur dans la région du lac Mistassini à deux stations distantes de 75 milles environ. Il est donc possible qu'elle soit répandue sous cette latitude partout où se réalisent ses exigences écologiques. Les premiers exemplaires furent capturés, le 12 juillet dernier, dans un pré humide en bordure d'un petit étang, au centre d'une tourbière. Une visite au même endroit, le 19 août, nous a fourni deux autres exemplaires. Le 4 septembre, un autre individu fut aperçu exactement au même point.

A la deuxième station où cette espèce fut capturée, des individus furent ramarqués en bordure d'un petit lac, ainsi qu'au-dessus d'un ruisselet alimenté par un pré tourbeux légèrement incliné. Les mâles vont et viennent à faible hauteur du sol détrempé, 2 à 4 pieds, sans doute à la recherche de femelles qui déposent leurs oeufs dans les eaux stagnantes.

***Somatochlora brevicincta* n. sp.**

Holotype mâle.—Labium et antéclypéus jaunâtres; labre en entier et postclypéus, sauf latéralement, d'un noir brillant; vertex et front en grande partie d'un vert métallique; les côtés et le milieu de la marge antérieure du front d'un jaune pâle; occiput d'un noir foncé. En vue antérieure, proéminence du vertex tronquée; marge supérieure du front distinctement creusée au milieu. Vestiture d'un brun foncé sur le dessus de la tête, l'occiput, le vertex et la partie horizontale du front; devenant plus pâle sur la partie verticale. L'arrière de la tête noir mais bordé d'une frange de cils blancs.

Prothorax d'un noir mat, sauf les lobes antérieurs et postérieurs qui sont jaunâtres. Méso- et métathorax d'un vert brillant, notablement voilé par la longue pubescence brune; portion supérieure des mésépisternes et une tache allongée sur le haut des mésépimères d'un jaune pâle; région ventrale du thorax grisâtre. Ailes hyalines, à l'exception du triangle anal et d'une partie des cellules qui le bordent toujours d'un ambre clair; stigma d'un brun jaune; membranule foncée dans les ⅔ apicaux, passant graduellement au blanc à la base. Pattes noires, à l'exception de la face postérieure des hanches, des trochanters et de la base des fémurs des pattes antérieures d'un brun jaunâtre.

Abdomen à 1er segment d'un brun noir; 2e segment d'un brun clair et brillant; auricules noires; 3e segment noir, sauf de chaque côté de la base où la coloration s'apparente à celle du segment précédent; segments 4-8 noirs, à l'exception d'une petite tache brunâtre aux angles antérieurs; segments 9-10 complètement noirs dorsalement; membrane intersegmentaire pâle aux segments 1 et 2, et

1Cette exploration entomologique a été possible grâce à une aide financière de l'Office de recherches scientifiques de la province de Québec et du Service de Biogéographie (Secrétariat provincial).

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partiellement sur les segments 8 et 9; ailleurs, elle montre la coloration du segment. Portion infléchie des tergites en grande partie noire, pâle seulement le long de la ligne médioventrale. Abdomen à peine plus long que les ailes postérieures, graduellement élargi à partir du 3e segment jusqu'à l'extrémité du 5e segment, à peine rétréci par la suite. Lobes génitaux contigus le long de la ligne médiane, à contours arrondis extérieurement; 10e sternite jaunâtre à l'extrémité.

Appendices supérieurs légèrement plus longs que les 9e et 10e segments réunis, à extrémité enroulée par le haut; marge externe pourvue d'une petite dent non loin de la base et sinuée à la suite de cette dent. Espace médian, d'abord près du double de la largeur de l'appendice, réduit graduellement vers l'extrémité. Vue de profil, la marge tranchante est continue et passe par la dent située vers le premier quart de sa longueur; elle est quelque peu sinueuse par la suite, mais passe par l'angle distal. Appendice inférieur triangulaire, allongé, environ les ¾ de la longueur de l'appendice supérieur, ⅓ environ plus long que large, à marges noires mais d'un brun jaune vu dorsalement et ventralement. Extrémité pourvue d'un denticule dorsal, situé un peu avant l'apex. Pubescence de l'appendice supérieur courte dorsalement, moins longue que la hauteur de l'appendice, mais beaucoup plus longue au bord médian où elle rencontre presque celle du bord opposé.

Allotype femelle.—Semblable au mâle pour ce qui est de la taille et de la coloration de la face et du thorax. Marge postérieure du triangle occipital bordée de longs poils roux. Ailes légèrement lavées de jaune brun, probablement en raison de l'âge du spécimen; membranule brune au ⅓ apical seulement, blanche à la base. Abdomen graduellement rétréci depuis la base jusqu'à l'extrémité. Taches latérales antérieures des segments 3 et 4 très grandes, semblables à celles du mâle sur les segments suivants; 10e segment jaunâtre autour du point d'insertion des appendices anaux. Ces derniers noirs, plus longs du tiers que les segments 9 et 10 réunis. Lame vulvaire horizontale, presque aussi longue que le 9e sternite, légèrement tronquée à l'apex, jaune à la périphérie, ornée au milieu de deux taches noires à contours diffus.

Nervation.—Nervures anténodales: ailes antérieures, ♂ 7-9, ♀ 7-9; ailes postérieures, ♂ 5-7, ♀ 6; nervures postnodales: ailes antérieures, ♂ 5-6, ♀ 5, ailes postérieures, ♂ 7-9, ♀ 7-9; nombre de cellules entre M1 et M1a: ailes antérieures, ♂ 13-19, ♀ 19-22; ailes postérieures, ♂ 14-20, ♀ 22. Triangles toujours pourvus d'une nervure transverse.

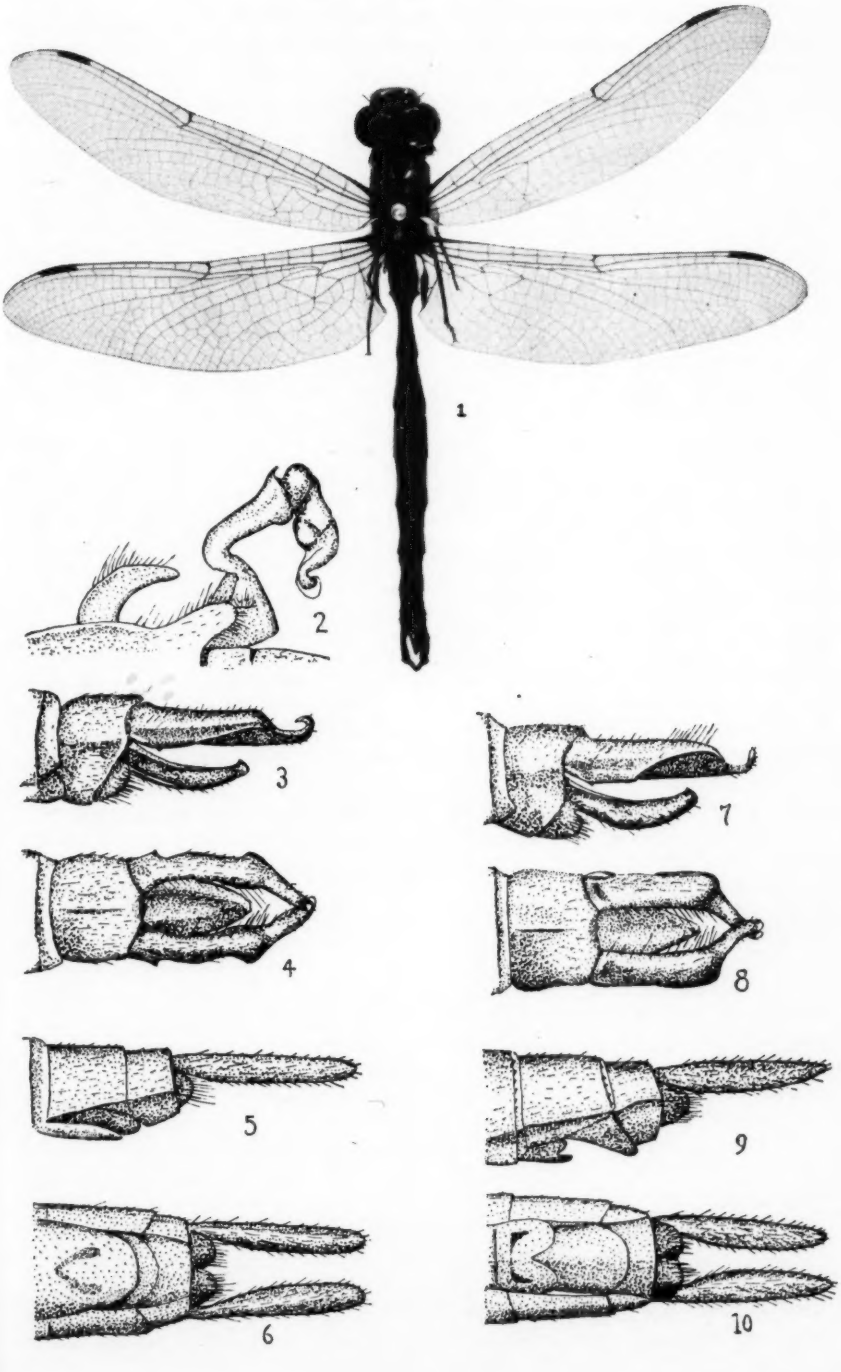
Dimensions: longueur totale, ♂ 47-50 mm, ♀ 44; thorax, ♂ 7-8, ♀ 8; abdomen, ♂ 28-31, ♀ 29; longueur du 5e segment abdominal, ♂ 3.8-4.2, ♀ 4.0; largeur du 5e segment, ♂ 2.9-3.1, ♀ 3.0; longueur de l'aile postérieure, ♂ 29-31, ♀ 30; largeur de l'aile postérieure, ♂ 9-10, ♀ 10; stigma, ♂ 2.4-3.0; appendices supérieurs, ♂ 3.1-4.0, ♀ 3.5; lame vulvaire, 2.0.

Holotype.— ♂, Tourbière, sise à un mille au nord du Poste, à l'extrémité sud-ouest du lac Mistassini, Nouveau Québec; long. 73°55′, lat. nord 50°25′; 12 juillet 1953 (A. Robert). Collection de l'Institut de Biologie, Université de Montréal.

Allotype.— ♀, Tourbière, sise au nord du Poste de Mistassini, N.Q. 19 août 1953, (R. Auger et A. Robert). Collection de l'Institut de Biologie, Université de Montréal.

Figures 1-6. *Somatochlora brevicincta* n. sp. 1. adulte mâle. 2. hamule et pénis. 3. profil du 10e segment et des appendices anaux. 4. vue dorsale des mêmes parties. 5. profil de l'extrémité de l'abdomen, femelle. 6. vue ventrale des mêmes parties.

Figures 7-10. *Somatochlora albicincta* Burm., 7. profil du 10e segment et des appendices anaux, mâle. 8. vue dorsale des mêmes parties, 9. profil de l'extrémité de l'abdomen, femelle. 10. vue ventrale des mêmes parties.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Paratypes.—2 ♂ capturés au même endroit et à la même date que l'holotype, (A. Robert); 2 ♂ capturés au même endroit que l'holotype, 19 août 1953 et 4 septembre 1953, (R. Auger et A. Robert); 2 ♂, capturés à ½ mille du lac Mistassini, près de l'extrémité sud-est. Long. 72°58′; lat. nord 51°41′, 31 août 1953, (R. Auger et A. Robert).

Cette espèce appartient évidemment au groupe *alpestris* tel que limité par E. M. Walker (1925). Par la coloration ambre du triangle anal des mâles, elle se rapproche de *S. hudsonica* et *S. cingulata*. Par contre, l'absence d'annulation blanche sur les segments médians de l'abdomen l'éloigne non seulement de *S. hudsonica* et *S. cingulata*, mais aussi de *S. albicincta*. Cette coloration sombre de l'abdomen incite à la ranger au voisinage de *S. whitehousei* ou de *S. septentrionalis* ou encore de *S. sahlbergi*, mais les deux premiers ont le triangle anal des ailes (mâles) franchement bruns, alors que chez *S. sahlbergi* ce triangle est hyalin.

L'un ou l'autre des caractères dont il vient d'être question nous permet de distinguer cette entité des espèces déjà décrites. Dans l'ensemble, sa ressemblance avec *S. albicincta* est plus accentuée qu'avec aucune autre, surtout à cause de sa taille et de la similitude considérable des appendices anaux. Toutefois, un examen minutieux permet de déceler des différences appréciables. Ainsi, en vue dorsale, le bord externe de l'appendice supérieur débute par une sorte de bourrelet arrondi chez *S. albicincta*, alors que cette portion est rectiligne dans la nouvelle espèce, et suivie d'une petite dent en général aigüe et bien marquée. De même, la marge tranchante de cet appendice supérieur, vue de profil, a une toute autre allure dans l'une et l'autre espèce.

Pour la distinction de cette espèce, on pourra se baser soit sur la forme des appendices supérieurs et leur grand écartement médian, soit sur la possession des caractères suivants: triangle anal ambré et annulation effacée sur les segments médians, apparente en partie seulement sur les segments 1, 2, 8 et 9; d'autre part, un oeil exercé voit dans la troncature du vertex et la profonde échancrure de la marge dorsale du front des indices de la présence de cette entité.

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A Laboratory Method for Rearing the Spruce Budworm, *Choristoneura fumiferana* (Clem.), (Lepidoptera: Tortricidae)[1]

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Introduction

This paper describes a method of rearing the spruce budworm, *Choristoneura fumiferana* (Clem.) under laboratory conditions. The development of such a method has been necessary as a preliminary step in a program of investigations into the genetics of the spruce budworm. The method therefore attempts to satisfy primarily the requirements of genetical studies but, since these are as exacting as may be necessary for any biological investigation, a wider applicability may be anticipated.

C. fumiferana is not a particularly suitable insect for laboratory study. In the field, it has but one generation per year; the natural food (young shoots of *Abies* and *Picea* spp.) is available only during a relatively short period of the year; and its life-cycle includes an extended hibernation period of about 10 months during the second larval instar. Although its fecundity is high (between 100 and 200 eggs), so is its normal mortality in the field and the laboratory, except, presumably, under those field conditions that allow it to increase numerically to epidemic proportions.

Efficient utilization of this insect in laboratory experiments therefore depends on achieving: (a) an increase in the number of generations that can be reared in a given period; (b) independence from the seasonal limitation in food supply, and (c) a reduction of mortality. Furthermore, it is desirable that the insects be readily accessible during all phases of the life cycle for observation and experimentation. Some of these objectives have been achieved with the method to be described.

General Methods and Conditions

The insects are kept and reared during all active stages in an air-conditioned rearing room of uniform temperature ($21.5 \pm 1°C.$) and a relative humidity of 68 - 75%. During hibernation the insects are stored in either of two cold rooms kept at 5°C. and 0°C. respectively.

To the present time no outbreaks of disease among the stocks have been experienced. Glassware is sterilized after use and the room furnishings are periodically washed with antiseptic solutions. On several occasions, however, the presence of viruses, microsporidia, bacteria, and pathogenic fungi has been observed.

The general rule has been established that, in so far as possible, the insects should not be handled directly. This is strictly enforced for first- and second-instar larvae, which are moved only by exploitation of their phototropic reactions. Later instars are allowed to drop from one place to another, instead of being picked up. Occasionally use is made of a soft brush. Only food buds and extraneous matter are handled with the aid of forceps or needles. Pupae should never be touched directly, but can easily be moved by means of their silk anchorage. Adults also need not be touched. They are enclosed in individual containers from which they can be dropped into mating cages. With some experience, losses caused by direct handling are avoidable.

Mating and Oviposition

For mating, the female and male are placed in a glass jar lined at the bottom and side with wax paper (Fig. 1). A balsam fir twig of the previous year's

[1]Contribution No. 155, Forest Biology Division, Science Service, Department of Agriculture, Ottawa, Canada.

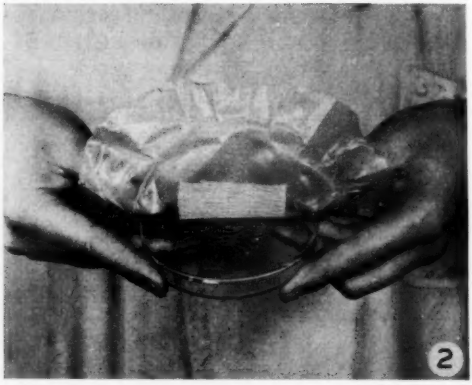

Fig. 1. Mating jar with foliage twig for oviposition.
Fig. 2. Petri plate with egg clusters mounted in the bottom, being sealed with gauze-parafilm.

growth, which has been dipped in water, is provided. The lid has an opening covered with wire screen for ventilation. Copulation frequently takes place in the evening of the same day, but may not occur for two or three days.

After mating, the male may be removed and discarded; only rarely will it mate successfully with a second female. The mated female is left undisturbed in its jar, where it will begin to lay eggs on the needles of the twig, usually by the afternoon of the day following the mating. To ascertain the age of the eggs the needles with clusters should be removed daily. Eggs laid on the waxpaper lining are secured intact by cutting the paper. Eggs are rarely laid after the seventh day, and then they usually prove to be infertile.

Hatching and Spinning

Six to eight days after the eggs have been laid, the first-instar larvae hatch. At least 24 hours before hatching, successful development of the embryo is indicated by the black head-capsule, which is clearly visible through the transparent chorion. At this stage the cluster-bearing needles, or pieces of lining, are glued to the bottom part of a Petri dish (16x100 mm) with rubber cement. The whole output of one female, or up to 12 clusters of average size, can be

Fig. 3. Insertion of Petri dish into light-mask.
Fig. 4. Placing the masked Petri dish on light table.

accommodated in one dish. The dish is then sealed with a piece of parafilm, pulled and pressed over the rim (Fig. 2). To the inside of the parafilm a double layer of gauze has previously been fastened by pressing it on firmly with a squeegee-roller. To protect the parafilm the upper part of the Petri dish is placed over it, and the dish is then put into a light mask—a simple bag or envelope made from dark paper and having a number of small holes on one side. The Petri dish is inserted with its gauze-parafilm next to these holes (Fig. 3). The closed envelope is placed on a light-table so that light passes from below through the holes and illuminates the semi-translucent parafilm where it is backed with gauze (Fig. 4). To avoid raising the temperature only reflected light is used in the light-table. The larvae hatching from the egg clusters directly above the gauze are attracted to it by the diffuse light (Wellington, 1948) and reach it by dropping. Suitable sites for spinning hibernacula are provided between the threads of the gauze mesh.

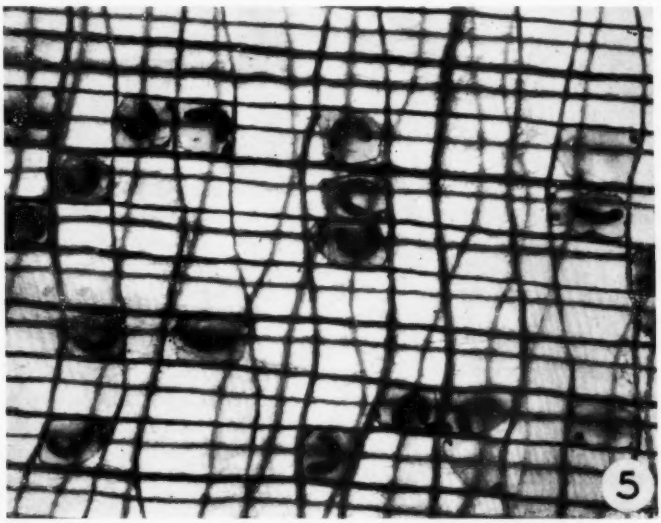

Fig. 5. Gauze mesh on parafilm and second-instar larvae in hibernacula.

Moulting takes place shortly after the hibernaculum is completed, and the shed head-capsule of the first instar is then to be found enclosed together with the second-instar larva. Unless some special care is taken of them, larvae leaving their hibernacula ("wandering seconds") have normally no chance of surviving (Harvey, 1954).

Hibernation

After time has been allowed for hatching, spinning, and moulting, all of which is completed within two weeks of oviposition, the larvae are left at rearing-room temperature for an additional two or a maximum of four weeks. Such a period may be necessary before cold storage to allow certain developmental processes to be completed, but the significance and optimal duration of this period is undetermined. However, to remain more than six weeks after oviposition at this high and constant temperature is decidedly harmful in terms of survival.

The films, with attached gauze and hibernacula, (Fig. 5) are transferred to a cold room for hibernation. Insects have been reared to maturity after a storage period of 26 weeks at 5°C., but survival is higher following either storage for shorter periods, between 12 and 25 weeks, or at 0°C. (Harvey, 1953). The requirements in time and temperature during hibernation are little understood and an investigation of these problems is in progress.

Food

The food used successfully at all times when fresh food is unavailable consists of deep-frozen balsam fir shoots (Bergold, 1951). Frozen foliage retards development somewhat, but has no known effects on fecundity or viability. A year's supply of freshly opened buds (1-3 cm) is collected in the spring and packed tightly into dixie cups, which are closed and sealed with wax. They are deep-frozen immediately (-70°C. for several hours) and may then be stored at -5°C. The food is taken from cold storage in small quantities as needed.

Emergence

Upon return to the rearing room for emergence from hibernacula, freshly thawed buds are added to the Petri dish with the gauze parafilm (Fig. 6). No water droplets should adhere to the buds, which may be dried gently between absorbent towels. If a numerical assessment of emergence is required, the food buds may be added after counting, but a moistened piece of filterpaper should then be placed into the dish to raise the humidity. The dishes are placed on the light-table, using light again to attract the second-instar larvae to their food. The rate of emergence from hibernacula varies with the time spent in overwintering, temperature, and humidity, and probably also with genetic constitution; the peak will rarely be reached, however, before the third day after removal from cold storage. As many as 20 to 30 larvae per family per day may emerge during one or two days, after which emergence falls off. To control the number of larvae per dish it may therefore be necessary to transfer the gauze-parafilm to new food dishes periodically (once or twice daily).

The size of the Petri dishes should not be under 16x100 mm to allow for enough food and to avoid crowding. The dish containing emerged larvae has to be well closed to prevent escape and should be kept dark to enhance establishment (Wellington, 1948). Parafilm gives a completely tight fit but prevents all ventilation, and moisture may accordingly condense inside the dish. Such moisture may be removed by frequent opening and gentle blowing.

Feeding

The food of the second- and third-instar larvae should not be changed during the first six to eight days; only after deterioration or fungus growth becomes excessive need it be replaced. At this time, an assessment of the numbers of established (feeding) larvae may be made. Occasionally, due to crowding or poor quality of the food, third- and fourth-instar larvae will chew through the film and enter the space between it and the covering dish, so that rather close surveillance is called for. Such dishes should be furnished with fresh food or, better, the number of larvae per dish should be reduced. In fourth-instar larvae, the testes show as dark spots, easily visible in transmitted light, and the two sexes may then be conveniently separated into different dishes. As soon as the larvae are too large to escape, the parafilm can be removed, leaving the feeding larvae observable from both sides of the dish.

Larvae of later instars not only tend to be cannibalistic but also compete for rather large amounts of food, between which they build their individual feeding tunnels, without actually eating all the food. Four to six larvae in the

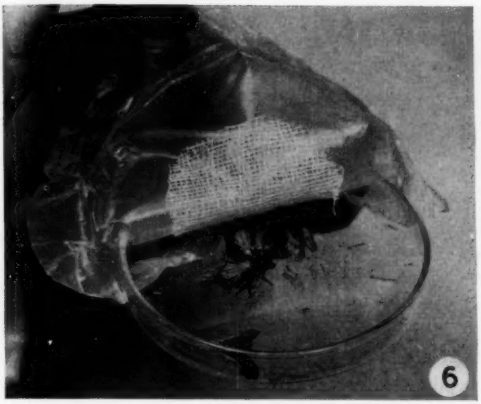

Fig. 6. Placing the gauze-parafilm with overwintered larvae over food.
Fig. 7. (a) Pupa, (b) emerged adult on absorbent paper in vial.

sixth instar may effectively monopolize all the available food in a dish, thus depriving other larvae of an adequate supply. Adding food or further reducing the population per dish will help to avoid such interactions between individuals.

Three to four weeks are necessary for development from emergence to pupation.

Pupation and Eclosion

Upon pupation, the pupa is placed on a piece of filter paper or paper towel in a screw-top vial (Fig. 7a). The paper prevents freshly moulted pupae from sticking to the glass, which otherwise leads to deformation. At the time of eclosion, the paper provides a rough surface on which the moth finds enough hold to free itself readily from the pupal case. Furthermore, it soaks up the meconium, discharged soon after eclosion, thus protecting the moth against soiling. The pupal stage lasts about seven days.

Several hours after eclosion, the insects may be paired for mating, the chances for success being highest within the first few days of adult life. Frequently the most desirable mates are not available on the same day: moths may then be stored in their tubes (Fig. 7b) at 5°C., where they will keep in good condition for eight to ten days. Occasionally, successful matings have been obtained with moths thus stored for more than three weeks.

Efficiency of the Technique

It may be helpful to give some data from which the efficiency of the laboratory method described in this paper can be assessed and compared with other results. On the average, 60-65% of all pairs set up for mating produced fertile eggs in normal numbers; 25-30% of the fertile eggs developed, after hatching and hibernation, to second-instar larvae established on the food; and 60-80% of these survived to maturity. Thus, from an original population of 20 mating pairs a minimum of 250 adults may be expected in the next generation, assuming a mean fecundity of 140 eggs per female. This is a six-fold increase per generation. Four consecutive generations of several stocks have been reared to date with the new technique without perceptible detrimental effects.

Mortality before establishment of the second-instar larvae on food remains the major factor reducing numbers during rearing. It is therefore an especially

valuable feature that the method ensures easy access to the individual insect for experimentation and observation during all stages of its life cycle, particularly during hibernation. It is here, in the conditions during hibernation, that further improvements are needed most and will most likely lead to significant increases in survival.

Summary

A laboratory rearing method for the spruce budworm is described, which makes it possible to rear several generations in one year.

Avoidance of direct handling during development, especially in the early larval stages, and easy access to the insects at all stages for observation, numerical assessment, or experimentation, characterize the technique. Overwintering mortality of second-instar larvae remains the major factor of numerical reduction of rearing stocks.

Acknowledgments

I wish to express my gratitude to Dr. S. G. Smith for his helpful advice; to Dr. G. T. Harvey for his advance communication of some experimental results; to Miss K. Bruce and Mr. I. M. Campbell for their assistance and cooperation; to Mrs. D. M. McNamee for identifications of diseases; and to Mr. D. C. Anderson for the photographs.

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A New *Phlyctaenia*, with Notes on Two Related Species (Lepidoptera: Pyralidae)[1]

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***Phlyctaenia quebecensis*, new species**

Body and wings pale buff, lightly dusted with darker; all markings obscure. Fore wing with antemedial line brown, very indistinct or obsolete; when discernible short, dentate, its general course at right angles to costa. Orbicular minute, punctiform, fuscous; reniform single, linear, concave outwards, fuscous. Postmedial line narrow, rather weak, fuscous, strongly and regularly dentate; its general course oblique outwardly from costa to M_2, thence gently curved basad to Cu_2 from which it proceeds perpendicularly, with one conspicuous angulation, to the inner margin. Beyond the postmedial a brown, strongly dentate, subterminal shade. Terminal line brown, broken between the veins; fringe pale buff. Hind wing with diffuse, dentate antmedial line and diffuse medial shades; postmedial, subterminal, and terminal markings as on fore wing. Under side as above, but with less brown shading; antemedial line absent, reniform and orbicular spots weak, postmedial line more diffuse and less strongly dentate than above.

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Length of fore wing 10-12 mm.

Genitalia as figured.

This species has been standing for some years in the Canadian National Collection without a name; now, thanks to the help of Messrs. Hahn W. Capps and E. L. Martin, I have eliminated several possibly applicable names and feel justified in describing the species as new. It closely resembles *extricalis* Gn. and *tertialis* Gn.; *extricalis*, however, has a diffuse dark shade in place of the dentate brown subterminal line of *quebecensis*, while *tertialis* is much more contrastingly marked and has the costal limb of the antemedial line of the fore wing hardly dentate.

Holotype male and allotype female: Lac Mondor, near Ste. Flore, P.Q.; July 12, 1951; E. G. Munroe; in the Canadian National Collection.

Paratypes:—In the Canadian National Collection: 12 males, 1 female, Lac Mondor, near Ste. Flore, P.Q., June and July; 2 males, 1 female, Lac à la Tortue, near Grand' Mère, P.Q., July; 2 males, Lanoraie, P.Q., July; 1 female, Mer Bleue, near Ottawa, Ont., June; 1 male, Armdale, N.S., July; 6 males, Mountain Lake, Va., July. In the collection of Charles P. Kimball, Barnstable, Mass.: 1 male, Monroe Co., N. Y., June; 2 females, Barnstable, Mass., July.

Type No. 6009, C.N.C.

***Phlyctaenia coronata tertialis* (Guenée), new status**

Ebulea tertialis Guenée, 1854: 364.

I am unable to detect any important difference in genitalia or maculation between the European *coronata* Hufnagel (better known as *sambucalis* Schiffermüller) and the well-known American *tertialis*. The American form has the dark markings paler and less sharply contrasting than does typical *coronata*, but the pattern is the same. The life-cycles of the two forms appear to be similar, and I therefore sink *tertialis* to *coronata* as a subspecies.

***Phlyctaenia extricalis* Gn.**

Botys extricalis Guenée, 1854: 338.

This species is divisible into two rather strikingly distinct subspecies: the more southerly one has an opaque ochreous ground colour, whereas that found in Eastern Canada has the ground colour whitish buff and the scaling rather thin.

***Phlyctaenia extricalis extricalis* Gn.**

Botys extricalis Guenée, 1854: 338.
Botys intricatalis Lederer, 1863: 373; 469; Pl. 10, Fig. 7.

Through the kindness of Prof. A. B. Klots, who loaned material from the American Museum of Natural History, I have examined 18 specimens of this subspecies, from the regions of New York, N. Y., and Philadelphia, Pa. The ochreous brown ground colour varies somewhat in depth, but is consistently deeper and brighter than in the northern subspecies. I do not know the full range of the subspecies. Guenée gives the locality of *extricalis* as "Amérique Septentrionale." His description of the ground colour as "jaune-roussâtre" seems sufficient to fix the subspecific application of the name. Lederer's figure of *intricatalis* is not entirely satisfactory, but the type, which I have examined in the Vienna Museum, is undoubtedly referable to the southern subspecies.

***Phlyctaenia extricalis dionalis* (Walker), new status**

Pionea dionalis Walker, 1859: 758.
Spilodes ?nisoeecalis Walker, 1859: 759.
Botis oppilalis Grote, 1880: 36.
Pyrausta beddeci Dyar, 1913: 139. New synonymy.

The pale northern subspecies of *extricalis* has a wide range in Canada, and probably also in the northern U.S.A. There are specimens in the Canadian

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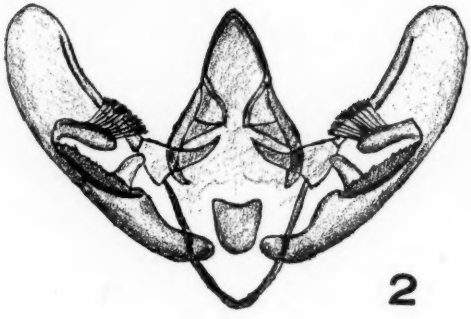

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Figs. 1-4. *Phlyctaenia quebecensis*. 1, ♀ paratype, Lanoraie, P.Q., June 17, 1934, A. C. Sheppard. 2, ♀ genitalia ventral aspect. 3, ♂ genitalia, ventral aspect, aedoeagus omitted. 4, aedoeagus.

National Collection from Newfoundland, Nova Scotia, New Brunswick, Quebec, Ontario, and Saskatchewan, and from Fort Simpson, N.W.T. I have seen what appears to be this subspecies from Monroe Co., New York.

Mr. E. L. Martin kindly examined the types in the British Museum and verified that *dionalis*, *nisoeecalis*, and *oppilalis* are conspecific; I have since veri-

fied the subspecific application of the names by personal examination of the types. The first two names are based on Nova Scotia material; *oppilalis* was described from Massachusetts and Maine. Mr. Hahn W. Capps has kindly compared Newfoundland specimens in the Canadian National Collection with the type of *beddeci* Dyar, from Codroy Valley, Newfoundland. The three Newfoundland specimens that I have seen appear to be a little smaller and darker than average mainland specimens, but the differences are very slight.

I have reared this subspecies from a leaf-roll on balsam poplar; the Forest Biology Division, Canada Department of Agriculture, has reared it from alder.

Acknowledgments

I wish to thank Mr. Hahn W. Capps, of the United States National Museum; Prof. A. B. Klots, of the American Museum of Natural History; and Mr. E. L. Martin, of the British Museum (Natural History), for assistance as detailed above. I must thank also Mr. Charles P. Kimball, Barnstable, Mass., who kindly loaned specimens of *Phlyctaenia quebecensis* from his collection.

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A Hibernation Record of *Ips plastographus* Leconte (Coleoptera: Scolytidae)

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An instance of the California pine engraver (*Ips plastographus* Leconte) hibernating in short tunnels in the sapwood of host trees was observed during an examination of a windfelled lodgepole pine forest at the 6,100-foot elevation on Parsnip Mountain, Kootenai National Forest (Lincoln County), Montana on September 27, 1950. The above examination disclosed that (1) the new adult beetles were overwintering in windfelled trees previously unattacked, and (2) the adults were seeking shelter in short tunnels that penetrated the bole sapwood of these trees.

Single beetles were found in numerous tunnels from ¼ to ½ inch in length which entered the sapwood radially and soon assumed a C-shape. The tunnels were round in cross section and slightly larger in diameter than the width of the beetles. The edges of the tunnel entrances on the outer sapwood surface were smoothly rounded as if from frequent ingress and egress of the beetles. The tunnels averaged in number about 0.8 per square inch of sapwood surface. Their entry ways occurred at intervals along irregular, winding galleries which scored the sapwood and inner bark surfaces. At the time of the examination beetles were moving freely in and out of the sapwood tunnels.

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The beetles appeared to be new adults, the progeny of parent beetles that initiated attacks in other windfelled trees earlier in the summer. The attacked windfalls averaged from 8 to 10 inches in diameter, breast height, with bark ranging from ⅛ to ¼ inch in thickness. The trees were uprooted by hurricane force winds in November 1949.

It is believed that the progeny beetles from the summer attacks emerged and sought refuge under the bole bark of previously unattacked windfelled trees early in September. The extensive system of winding galleries between the inner bark surface and the sapwood appeared to be adult feeding tunnels, since there was no suggestion of nuptial chamber or egg gallery construction. The beetles might have hibernated in the feeding tunnels or under the bark more or less en masse, but presumably the thin bark did not offer sufficient protection from below-freezing night air temperatures which continued uninterrupted after September 7. This may have forced the beetles into the sapwood for further protection.

While it is known that some species of *Ips* overwinter as new adults in trees other than the larval hosts, the present record of sapwood burrowing is believed to be unique. It is not known whether this is an isolated example forced by circumstances or whether it may be a more common overwintering habit of *I. plastographus* under certain conditions.

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